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A
TOPOGRAPHICAL ATLAS
OF THE
SPINAL CORD

BY

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1901.

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Dedicated

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TRUSTEES OF THE LATE
WILLIAM RAMSAY HENDERSON,

WHO, OUT OF THE FUNDS AT THEIR DISPOSAL,
ASSISTED IN THE PRODUCTION
OF THIS WORK.

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PREFACE.

THE aim of the Author in producing this Atlas of the Spinal Cord of a normal human adult has been to provide representations of sections regarded as typical of each of its segments with a view to determine *(a)* the relative arrangement of the grey and white matter, and especially the form of the anterior cornu characteristic of each segment; *(b)*, the distribution of the motor nerve cells, and the relation of the distribution and number of these cells to the conformation of the anterior cornu; and *(c)*, other features which may serve for the identification of any segment in which the form of the anterior cornu is not sufficiently distinctive for that purpose.

It is hoped that the normal standards thus provided may not merely prove useful for the identification of the segment to which sections submitted for examination belong, but may serve as a basis for comparison with pathological conditions, and as an aid to the study of localisation of the motor functions of the Cord.

The method of procedure adopted has been as follows:—A Spinal Cord from an adult who was free from any sign, symptom, or *post-mortem* evidence of any disease of the nervous system has been selected. It has been fixed and hardened by a process which allowed the nerve cells and the myelin of the nerve fibres to be equally well stained in separate sections. The Cord has then been divided into its various segments, and each segment cut throughout its entire length into serial microscopic sections of uniform thickness. Two series of sections were prepared; the one (Series A) to demonstrate the arrangement of the nerve cells, and the other (Series B) the shape of the grey matter characteristic of each segment. The typical sections in each series have been photographed under a uniform enlargement, and the photographs reproduced by the photogravure process. Every care has been taken to secure that each figure should be an accurate, unsophisticated representation of its corresponding section, and it has been thought advisable to leave the Plates to speak for themselves, and not to interfere with them by lines or marks to indicate the position of cells or other structures.

Special recognition must be made of the care with which the photographs were taken by Mr Richard Muir, of the Pathological Laboratory of the University of Edinburgh, and of the skill with which the photogravures have been produced by Messrs J. & T. Annan & Sons of Glasgow.

ALEXANDER BRUCE.

8 Ainslie Place, Edinburgh,
Christmas 1900.

INTRODUCTION.

THE Spinal Cord which was employed in the investigation was obtained from a young adult female. It was the last of a series of five that had been completely examined and was the only one of these that satisfactorily fulfilled the requirements of being free from flaw and from evidence of any morbid condition.

The fixing re-agent finally selected, on the recommendation of Dr Ford Robertson, the Director of the Laboratory of the Scottish Asylums, was Weigert's chrome-alum-copper solution.* The stain for the myelin sheath of the nerve fibres was Ford Robertson's modification of Heller's method.† In staining the nerve cells, toluidin and polychrome blue were employed,‡ care being taken not to push the decolorisation beyond the stage at which there was still a distinct indication of the difference between the grey and white matter, and at the same time a complete staining of the nerve cells.

The Spinal Cord, which was in a state of good preservation, was removed along with its dural sheath twenty-four hours after death, and was placed immediately in the chrome-alum-copper solution. After a few days it was divided into its segments, and replaced in the solution for fourteen days in order to complete the hardening process. The upper boundary of each segment was made by a transverse incision immediately below the most inferior of the roots which entered the segment above. The lower boundary was formed by a transverse incision immediately below the lowest root which entered the segment itself. Care was taken to determine each segment by tracing its roots from their opening in the dura mater. Each segment, after being

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* Weigert's chrome-alum-copper solution is prepared as follows:—2½ grammes of chrome alum are dissolved by boiling in a 100 c.c. of water. The solution is filtered when cold and 5 grammes of acetate of copper, 5 c.c. of acetic acid, and 10 c.c. of formalin are added.

† Ford Robertson's modification of Heller's method:—

1. Place the section in 1 per cent osmic acid for one hour (in the dark). Wash in water.
2. Then in 5 per cent of pyrogallic acid for half an hour. Wash in water.
3. Then in ¼ per cent potassium permanganate for four minutes. Wash in water.
4. Then in 1 per cent oxalic acid for three to five minutes. Wash in water, dehydrate, clear, and mount in balsam.

‡ Ford Robertson's Toluidin blue method:—

Stain from 15 to 60 minutes in ¼ per cent aqueous solution of Toluidin blue. Decolorise and dehydrate in absolute alcohol, clear first in benzole, then in turpentine and benzole. After heating to drive off all water of condensation, apply a drop of balsam and a coverglass, which should be also warm. The warming of the section and coverglass are, according to Robertson, essential to the permanence of the stain.

sufficiently hardened, was mounted in celloidin in the usual manner, and then cut into microscopic sections of uniform thickness on a sliding microtome. Of the serial sections thus obtained every tenth one was stained by the modified Heller's method for blackening the myelin sheath, in order to demonstrate the relative arrangements and proportion of the grey and white matter. From the total number of sections in each segment a selection was made of one which appeared to be the most characteristic of the segment. Where the transition in form of the grey and white matter in any one segment was so great that a single section could not be regarded as typical of that segment (as was the case in the eighth cervical segment), two sections were chosen. The sections of this whole series have been photographed with a magnification of ten diameters.

For the demonstration of motor nerve cells in the grey matter, a similar selection of every tenth section was made. These were stained by toluidin blue. As in the former case, a typical section (or, where it appeared advisable, more than one) was selected from each segment, and its grey matter photographed with a magnification of twenty diameters.

In comparing the anterior cornua at the various levels of the cord, it will be found that the grey matter is constantly varying in shape, but that the form assumed at each segment is characteristic of that segment. It is, perhaps, more accurate to use the expression *type of form*, because, although the general plan of the cornu in each segment is the same in all cords, it will be found that there are minor individual variations which appear to be mainly dependent upon differences in the shape of the cord. Thus in some cords which are flatter anterio-posteriorly than others, the cornu is correspondingly flattened and has a greater transverse diameter than in the cases where the cord is more nearly circular. In spite of these differences, it will be seen that what one may term the *type of outline* of the anterior cornu is constant for each segment or for corresponding parts of segments in different cords. For example, the cornu of the fifth cervical segment is characterised by three somewhat pointed projections with two concavities between them. In a more rounded cord, although the cornu would be more compressed laterally, the typical projections and the concave outlines would still be present, and would suffice to differentiate this segment from all others. These types are most easily distinguished in the cervical and lumbo-sacral regions, and as they are best appreciated by a comparison of the various representative figures, no detailed description of them need be given. In the dorsal region, where the transition from segment to segment is less abrupt, the differentiation may become a matter of extreme difficulty, especially from the third to the tenth segment. The alteration in the form and size of the anterior cornua is evidently correlated with the number and grouping of its contained motor cells, as will be shown in the sequel.

The Plates show in a striking manner how the lateral groups of cells in the cervical and lumbar enlargements, which may be presumed to innervate the muscles of the limbs, form a lateral projection to the outside of an area which has a general correspondance in form with the anterior cornu of a typical dorsal segment. The form of this lateral projection is determined by the distribution and number of the motor cells for the limbs. In the majority of the cervical and lumbar segments, as also in the dorsal and sacral, the anterior cornu presents three angles, a mesial, an antero-lateral, and a postero-lateral, and four margins, an inner, an anterior, an antero-lateral, and a posterior. Departures from this arrangement are found in the lower part of the eighth cervical, in the first dorsal, and in the third, fourth, and fifth sacral segments, and are dependent on the disappearance of certain groups of nerve cells.

With regard to the distribution of the motor cells in the anterior cornua, an examination of the figures in series A (the upper figure in each Plate) shows that, in the cervical and lumbar regions and in the first dorsal segment, these may be for the most part divided into a *mesial* and a *lateral* cell column.

The *mesial column* of cells is present throughout the entire length of the cord above the fifth sacral segment, with the exception of the fifth lumbar, first sacral, and upper half of the second sacral.

Although it is beyond the intention of the present work to enter into the question of the localisation of function of the motor cells, it may be noted that the continuation of this column throughout practically the whole length of the cord, with the exception of the above-mentioned segments (which are almost certainly centres for the innervation of the lower limbs), affords strong presumptive evidence that it supplies muscles of the trunk. This view agrees with that of Kaiser (2), Sano (3), van Gehuchten (4), and others. In no one section is the number of its cells great; never exceeding fifteen, and sometimes being as low as one. In some sections a second mesial group, lying behind the one which is situated near the tip of the anterior horn, seems to deserve a special name. Thus an *anterior mesial* and a *posterior mesial* group may be differentiated in some instances, especially throughout the dorsal region. When a posterior group is present, its cells are smaller than those of the anterior mesial group.

The *anterior mesial* group attains its maximum development, both as regards the size and the number of its cells, in the fourth and fifth cervical segments. In these there is a large circumscribed collection of cells to the outer side of the usual portion of the anterior group. This in all probability represents the spinal centre for the phrenic nerve. In the cervical region, below the fifth segment, the cells of the mesial group gradually diminish in number, in many sections only one or two cells, or even none at all being found. At the lower part of the eighth cervical segment there is again a sudden increase in the number of its cells—an increase which is maintained throughout the whole of the dorsal region. In the four upper lumbar segments it is well represented. In the first, second, and third segments (L. 1. 2. 3.) a few cells in a small antero-lateral angle may be included along with the mesial group, or regarded as a special *anterior* group, having no relation with the ordinary antero-lateral cell column. In the fifth lumbar, first sacral, and upper part of the second sacral segments, the mesial group is unrepresented. It reappears, however, in the lower part of the second sacral segment, and is continued as low as the fourth sacral segment, where it is represented by ten cells of remarkably large size. The mesial group is not found at the fifth sacral segment.

The *lateral* cell column can be further subdivided in the cervical region into an *antero-lateral* and a *postero-lateral*, and, at the seventh and eighth segments, a *post-postero-lateral* portion. In the dorsal region the first segment contains a large number of cells belonging to the post-postero-lateral column. The lateral column of large motor cells is otherwise unrepresented in the dorsal region. In the lumbo-sacral region an *antero-lateral* and a *postero-lateral* column are found as far down as the lower end of the second and third sacral segments respectively. There is, in addition, from the second lumbar to the upper part of the second sacral inclusive, a *central* group internal to those above mentioned; and at the first, second, and third sacral segments, the small group behind the postero-lateral, which may be termed (as in the cervical region), with Onuf, a *post-postero-lateral*, or with van Gehuchten, a *secondary postero-lateral* group.

In the cervical region the *antero-lateral* cell column appears first at the fourth segment as a collection of some six cells. It rapidly increases in size and in the number of its cells in the fifth segment, in which it is responsible for the development of the prominent antero-lateral angle. Within the sixth segment a remarkable change, at first sight difficult to interpret, takes place in the position and size of the antero-lateral group. The antero-lateral angle, and, with it, its corresponding group of cells, become displaced in an inward direction. The number of cells within the group diminishes rapidly, and, at the same time, between it and the postero-lateral group a new collection of cells appears. This group is the cause of the projection seen between the antero-lateral and postero-lateral angles. (See Plate VI. B, right side.) Examination of the rest of the series of sections in the lower half of the sixth segment and the upper part of the seventh (these have not been figured), revealed the fact that the antero-lateral group already described diminishes in importance and finally disappears entirely in the upper part of the seventh segment. At the same time the new intercalated group of cells increases in size and occupies the antero-lateral projection in this segment. [It will be noted that the new antero-lateral angle is much further removed from the mesial angle in the seventh than was the old one in the sixth segment.] The new group thus formed, when traced through a series of sections, is found to enlarge gradually and to become continuous with the antero-lateral group of the seventh and upper part of the eighth segments. This column of cells may be termed *lower antero-lateral*, while that present in the fourth and fifth, and terminating in the upper part of the seventh segment may be termed *upper antero-lateral.* There are thus in the cervical region two antero-lateral columns of cells. One of these, the upper antero-lateral, extends from the upper limits of the fourth to the upper part of the seventh segment, and attains its maximum development in the fifth segment. The other, or lower antero-lateral, extends from the upper third of the sixth to the middle of the eighth segment, and attains its maximum development at the seventh segment. The two antero-lateral groups thus co-exist in the sixth segment.

Within the eighth segment the lower antero-lateral group passes a short distance inwards towards the mesial angle, and comes to occupy a position midway between this and the postero-lateral projection. This has at the same time advanced towards the anterior surface of the cord, so as to be all but on the same plane as the mesial angle. These changes take place within the upper part of the segment. Its lower portion is characterised by the gradual diminution and disappearance of the antero-lateral group, and with it the antero-lateral angle. In consequence of this change the anterior and antero-lateral margins of the cornu become merged into one continuous curved line, with its concavity directed forwards. An examination of Plate IX. shews that the antero-lateral group is no longer present.

In the fifth and eighth segments there is an indication of subdivision of the antero-lateral group into three subordinate nuclei, of which one occupies an anterior, one an inner, and one a posterior position. The most anterior portion of the upper antero-lateral group appears to be continued into the sixth segment. In the seventh, subdivision is not definite, although the arrangement of the cells is not uniform throughout the group.

The *postero-lateral* cell column appears at the lower part of the fourth segment as a small group of some four cells. Its numbers increase very rapidly, and attain their maximum in the fifth and sixth segments, where they form the prominent postero-lateral angle. Within the seventh segment there is again a diminution of the number of its cells to about one-half of that found in the fifth and sixth segments. This diminution is associated with a retraction of the postero-lateral angle and a shortening of the posterior margin, and affords an explanation of the fact that the antero-lateral angle in the lower part of the segment is actually external to the postero-lateral. In the upper portion of the eighth cervical segment the number of the cells in the postero-lateral group again increases to practically the same as that which is found in the fifth and sixth segments. Coincidently there is a great increase in the size of the postero-lateral projection. The examination of a series of sections in the upper part of the eighth segment shewed that the remarkable alteration in its form is due mainly to the great increase in size and to the forward growth of the postero-lateral group of cells. It will be noted in figure C. 8. a., Plate VIII., that a segments it is well represented. In the first, second, and third segments (L. 1. 2. 3.) a few cells in a small antero-lateral angle may be included along with the mesial group, or regarded as a special *anterior* group, having no relation with the ordinary antero-lateral cell column. In the fifth lumbar, first sacral, and upper part of the second sacral segments, the mesial group is unrepresented. It reappears, however, in the lower part of the second sacral segment, and is continued as low as the fourth sacral segment, where it is represented by ten cells of remarkably large size. The mesial group is not found at the fifth sacral segment.

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The *postero-lateral* cell column appears at the lower part of the fourth segment as a small group of some four cells. Its numbers increase very rapidly, and attain their maximum in the fifth and sixth segments, where they form the prominent postero-lateral angle. Within the seventh segment there is again a diminution of the number of its cells to about one-half of that found in the fifth and sixth segments. This diminution is associated with a retraction of the postero-lateral angle and a shortening of the posterior margin, and affords an explanation of the fact that the antero-lateral angle in the lower part of the segment is actually external to the postero-lateral. In the upper portion of the eighth cervical segment the number of the cells in the postero-lateral group again increases to practically the same as that which is found in the fifth and sixth segments. Coincidently there is a great increase in the size of the postero-lateral projection. The examination of a series of sections in the upper part of the eighth segment shewed that the remarkable alteration in its form is due mainly to the great increase in size and to the forward growth of the postero-lateral group of cells. It will be noted in figure C. 8. a., Plate VIII., that a small group of three cells appears behind the inner part of the postero-lateral nucleus. As this group forms the upper extremity of a column of cells which becomes of importance in the lower half of the segment and in the first dorsal, it may be termed, as in the lumbo-sacral region, the *post-postero-lateral* group.

In the lower part of the eighth segment, the postero-lateral projection is of greater size than at any other part of the cervical region, and forms the large, rounded, outer part of the horn. On examination it is found to be occupied by a large collection of cells arranged in two main groups [separated from each other by a blood-vessel passing obliquely across the outer part of the horn]. Of these the larger and more anterior belongs to the postero-lateral group, and the smaller one behind it (which seems capable of further division into two parts), belongs to the post-postero-lateral column.

In the first dorsal segment, which, both on anatomical and physiological grounds, has more affinity with the cervical region than with that from which it obtains its name, the postero-lateral projection still remains prominent, but less so than in the eighth cervical. It has also receded further from the anterior surface, so that it no longer forms the outer lip of the cup which is characteristic of the anterior cornu in the lower part of the eighth cervical segment. This transition in form is due to the disappearance of the postero-lateral group, which has taken place gradually through the lower part of the eighth segment, and to the development of the post-postero-lateral group.

TABLE OF MOTOR CELLS in the various Groups in the Anterior Cornua of Representative Sections from each Segment of the Cervical Region.

	Anterior Mesial.	Posterior Mesial.	Antero-Lateral.		Postero-Lateral.	Post Postero-Lateral.	Phrenic.	Spinal Accessory.
			Upper.	Lower.				
C. 1,	13	8	...	...	...	...	...	16
C. 2,	12	...	...	...	...	...	...	8
C. 3,	12	...	...	...	...	...	...	5
C. 4, a,	10	...	...	...	...	...	17	...
C. 4, b,	6	...	6	...	4	...	18	7
C. 5,	15	...	27	...	31	...	...	...
C. 6,	9	5	11	7	30	...	...	...
C. 7,	4	5	...	35	16	...	...	...
C. 8, a,	4	...	...	29	30	3	...	...
C. 8, b,	7	...	...	...	31	21	...	...

In the lumbo-sacral region, the lateral group of motor cells is first represented at the second segment. It is true that at the antero-lateral angle of the first segment there is a small group of cells, and that in a corresponding position in the second and third segments there is a small group of cells of similar character; but these are so obviously different in their size and staining capacity from the ordinary motor cells in the rest of the lumbo-sacral region, and so distinctly separated from the mesial group, that it seems better to class them apart as a special *anterior* group.

The *antero-lateral* cell column begins at the second lumbar segment as a small group of ten cells; extends without material change through the third segment; then rapidly increases through the fourth and fifth lumbar segments, where it causes a special projection of the antero-lateral angle. It reaches its maximum size at the first sacral segment; diminishes rapidly through the upper part of the second, and entirely disappears before the third segment is reached. The determination of its lower limit is a matter of some difficulty, the reasons for which will be considered at the end of the paragraph on the postero-lateral column.

The *postero-lateral* cell column begins somewhat abruptly with a large group of cells at the second lumbar segment, increases rapidly through the third, and attains its maximum size in the fourth and fifth lumbar segments. In the first sacral segment the number of cells becomes greatly diminished although the group still remains of large size. This diminution continues somewhat gradually through the second segment, and in the third becomes very considerable. The column ceases entirely at the lower part of the third segment.

As already said in considering the antero-lateral column, it is somewhat difficult to determine the lower extremities of the antero-lateral and postero-lateral cell columns in the sacral region. This is due to the fact that the postero-lateral and post-postero-lateral columns become displaced forwards into the position previously occupied by the antero-lateral and postero-lateral columns respectively.* The postero-lateral column passes into the position previously occupied by the antero-lateral column, while the post-postero-lateral column passes forwards into that vacated by the postero-lateral column. This will be seen if the two sides of Fig. S. 2. (B), and if Fig. S. 2. b. (A) be studied. In S. 2. b. it appears at first sight as if the two large groups of cells were merely the antero-lateral and the postero-lateral group continued down from S. 2. a., the central and post-postero-lateral groups having disappeared. That this is not the case however is seen when the whole series of sections between S. 2. a. and S. 2. b. has been analysed. In these it is found that the antero-lateral group has gradually become reduced in size, and that the postero-lateral group, while also diminishing in the number of its cells, passes forwards, and almost coalesces with the disappearing antero-lateral group. For this reason the two groups in the anterior cornu in S. 2. b. are readily mistaken for the antero-lateral, whereas, in reality, only the nine cells in front belong to the antero-lateral group, and the twenty-two cells in the large nucleus behind belong to the postero-lateral group. In a similar manner the post-postero-lateral group has passed forwards, the number of its cells, however, increasing instead of diminishing. It has been impossible to reproduce a sufficient number of sections to demonstrate this transition, but an indication of the process may be obtained from a study of the two sides of the lower figure in Plate XXVIII. (S. 2. B.). The section from which this was made was slightly oblique, the plane of its right side being lower than its left, and therefore showing a more advanced stage of the transition. At first sight the two projections on the right side appear to be merely the same antero-lateral and postero-lateral projection as in S. 1. B, but a more careful examination shows that there are not two, but really three projecting masses—a very small one anteriorly ; a large one immediately behind this, only imperfectly separated from it ; and a third, still larger, at the postero-lateral angle, separated from the second by a considerable surface depression. If the left side of the figure be now examined, the earlier stage of the transition is seen. There are still three projections,—anterior, intermediate, and posterior. The first of these, *i.e.*, the anterior, distinctly separated from the second or intermediate, is undoubtedly occupied by the antero-lateral group of cells, and corresponds to the small anterior projection on the right side of the figure, and to the large antero-lateral projection of S. 1. B. The intermediate projection, of large size and indistinctly separated from the small posterior projection, represents the postero-lateral mass of cells of S. 1. displaced forwards by the increasing number of cells in the post-postero-lateral group, which now occupies the most posterior of the three projections, and forms the postero-lateral angle.

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* This view is in harmony with that expressed by Onuf and by van Gehuchten (*loc. cit.*).

In the lower part of the sacral segment the antero-lateral group of cells and its corresponding projection disappear first, then the postero-lateral group diminishes rapidly, the attenuated post-postero-lateral group persisting longer. In this manner the alteration in the shape of the anterior horn in S. 3. is brought about. The analogy to the transition found in the eighth cervical and first dorsal segments will at once suggest itself. In them there is a disappearance of the antero-lateral group in the lower part of the eighth cervical segment, and an appearance of the post-postero-lateral group which has become sufficiently large to displace the postero-lateral group forwards. In the first dorsal segment the postero-lateral group of cells has disappeared, and only the post-postero-lateral group is formed.

Throughout the whole length of the postero-lateral column, the cells at any given level are invariably more numerous and larger in size, than are those of the antero-lateral group.

The *post-postero-lateral* column appears above as a small group of seven cells at the first sacral segment. Its size remains essentially unaltered in the upper half of the second sacral segment. In the lower half of this segment it increases rapidly, so that its cells are about four times as numerous as at the higher levels, and occupy the postero-lateral angle of the horn. [As already explained, at this level they are apt to be confused with the postero-lateral group, an error to be avoided by realising and remembering that the postero-lateral group has passed forwards almost into the position previously occupied by the antero-lateral group.] This post-postero-lateral column rapidly diminishes through the third segment, where it will be noted, however, that its numbers preponderate over those of the postero-lateral group. The column entirely ceases at the lower limit of the third sacral segment.

The *central* cell column, which appears to have no homologue in the cervical region, extends from the second lumbar to the upper part of the second sacral segment. Throughout its entire course it forms a fairly compact column of cells, to the inner side of, and between, the antero-lateral and postero-lateral group of cells. The number of the cells is at its maximum at the fifth lumbar, and first sacral segments, the increase from the apex being gradual, the diminution to its lower limit being rapid. It ceases entirely at the upper part of the second sacral segment.

TABLE OF MOTOR CELLS in the various Groups in the Anterior Cornua of Representative Sections from each Segment of the Lumbo-Sacral Region.

	Anterior Mesial.	Posterior Mesial.	Anterior.	Antero-Lateral.	Postero-Lateral.	Post Postero-Lateral.	Central.
L. 1,	5	3	3	...	...	...	...
L. 2,	7	...	4	10	26	...	3
L. 3,	5	...	4	8	35	...	12
L. 4,	6	...	4	24	50	...	11
L. 5,	...	...	...	22	50	...	18
S. 1,	...	...	...	33	34	7	20
S. 2, a,	...	...	...	20	31	6	11
S. 2, b,	1	...	...	9	22	25	...
S. 3, a,	5	...	...	...	7	22	...
S. 3, b,	3 + 5	...	...	...	6	10	...
S. 4,	10	...	...	...	...	...	...
S. 5,	...	...	...	...	...	...	...

In comparing the figures (Plates XXII.-XXXI.) from the lower series (B) of the lumbo-sacral regions, it will be seen that the transition in the form of the anterior cornu from segment to segment is at least as great, or, considering the length of cord involved, even greater than in the cervical region; and that the type of outline in the anterior cornu in each segment is equally characteristic. Possibility of confounding different segments can arise only between the second and third lumbar, between the fourth and fifth lumbar, between the first and second sacral, and between the third, fourth, and fifth sacral segments. Such errors can easily be avoided if attention be paid to the special distinguishing features of each of these segments. Thus, the anterior cornu of the third lumbar segment is distinguished from that of the second by its greater size, its forward convexity, and by the lesser prominence of the mesial angle. The fifth lumbar is distinguished from the fourth by the prominence and backward direction of its postero-lateral projection, as well as by the marked depression between the antero-lateral and postero-lateral projections. The first sacral segment is differentiated from the second by the greater prominence of the antero-lateral and postero-lateral projections. In the second sacral segment the antero-lateral projection has greatly diminished in size, while the post-postero-lateral projection has displaced the postero-lateral into an intermediate position. Consequently in the second sacral segment there are really three lateral projections. The third, fourth, and fifth sacral segments are characterised by the prominent mesial angle (absent in all segments from the third lumbar to the second sacral inclusive) and by the convex outline of the lateral part of the cornu. These three segments are distinguished from each other by the relative size of the anterior and posterior cornua. In the fourth segment they are nearly equal in size; in the third the anterior, in the fifth segment the posterior cornu is the larger of the two.

If the upper and lower figures in each Plate be now compared, it will be seen how close is the relationship between the form and size of the cornu on the one hand and the grouping and number of its cells on the other. The prominent mesial angle of the first lumbar is occupied by the anterior mesial group of cells; its prominent postero-lateral angle by the intermedio-lateral cells and the slight antero-lateral projection by the anterior group of cells. In the second lumbar segment the prominent mesial angle is occupied by the anterior mesial cells, the rounded lateral mass, devoid of distinct antero-lateral or postero-lateral angle, is occupied by two groups of cells, only imperfectly differentiated from each other. The third segment has fewer mesial cells, and, consequently, a less prominent mesial angle. The number of cells in its lateral group is large; but the imperfect subdivision into an anterior and a posterior group is indicated by the want of distinct antero-lateral and postero-lateral projections in the cornu. So soon as this differentiation between antero-lateral and postero-lateral group appears, the antero-lateral and postero-lateral projections become distinct, while their size and position are in strict relation to the size and position of these groups (as in the fourth and fifth lumbar and first sacral). The diminution of the antero-lateral group and the rise of the post-postero-lateral group are expressed by the change of form in the anterior cornu of the second sacral segment, as has been already fully explained. The absence, in the fourth and fifth lumbar, and first and second sacral segments, of a mesial angle is due to the disappearance from these segments of an anterior mesial group of cells. The reappearance in the third sacral segment of a mesial cell-group is coincident with the reappearance of an anterior mesial angle. The replacement of an antero-lateral and a postero-lateral projection by a rounded margin from the mesial angle to the post-postero-lateral projection, is due to the disappearance first of the antero-lateral, and then of the postero-lateral, group of cells.

From what has been said, it will be seen that, as soon as the arrangement of the motor cell group in the anterior cornu and the form of the cornu, which depends upon that arrangement, have been fully appreciated, it becomes a comparatively simple matter to recognise any one segment in the cervical or lumbo-sacral region. Although there may be certain variations in the form of the anterior cornu in the corresponding segments in the spinal cords of different individuals, the characteristic type of outline is maintained in each segment, and should enable it to be readily identified. While this is the case with regard to the cervical and lumbo-sacral regions, the same does not obtain in the dorsal portion of the cord. Here the comparative uniformity in the distribution and function of the muscles innervated from this portion of the cord has led to a similar want of variety in the shape of the anterior cornua and their contained motor cells. In several segments, however, distinctive features can be demonstrated. On examining the Plates X.-XXII., it is seen that the first, second, eleventh, and twelfth segments have features, both in their anterior and posterior cornua, which are peculiar to, and characteristic of them. The first dorsal has, in its anterior cornu, a large projecting lateral mass, its concave surface directed forwards and outwards, and a comparatively broad posterior horn, with a somewhat blunt point. The second dorsal segment shows a great change from the first. The large projecting lateral mass with its rounded point has been replaced by a somewhat short but sharp point. The rest of the anterior cornu has nearly the form of that part of the first dorsal segment which would remain if the projecting lateral mass, as indicated by the darker stain of its contained medullated fibres, were removed. It has a distinct anterior and an antero-lateral angle, and an oblique anterior surface. The posterior cornu is still comparatively broad, though not quite to the same degree as in the first dorsal segment, and does not show the distinct constriction at the neck which is found in all lower dorsal segments. The portion of the margin of the posterior columns which is in contact with the posterior commissure forms an almost straight line.

The eleventh and twelfth dorsal segments are characterised by the peculiar shape of the posterior cornu, with its constricted neck, its heel on the inner side, its increased breadth, and its pointed extremity; by the large size of the column of Clarke, which makes a marked projection into the posterior column; by the size and shape of the anterior cornua, which show an oblique anterior surface; and by the remarkably sinuous outline given to the outer margin of the posterior column by the column of Clarke, and the projecting heel of the posterior cornu. The segments differ from each other in several important points. In the twelfth segment the grey matter as a whole is larger. The increased size of the column of Clarke has broadened the base of the posterior cornu, and has pushed out the postero-lateral angle of the anterior cornu, so that the antero-lateral surface is oblique, and not, as in the eleventh segment, parallel to the inner surface.

It is very difficult, if not impossible, to identify individual segments in the rest of the dorsal region, viz., from the third to the tenth inclusive. It is, however, possible to tell whether any given segment belongs to the upper part, viz., from the third to the sixth inclusive, or to the lower, viz., from the seventh to the tenth inclusive. If attention be paid to the column of Clarke, and the effect of its presence on the anterior portion of the posterior column, it will be observed that from the third to the sixth segments the column of Clarke is so slightly developed that it does not depress the portion of the posterior columns adjacent to it. Consequently the anterior extremity of the combined posterior columns remains comparatively broad and flat, and their outline from the middle line to the gelatinous substance is convex outwards. In contrast to this, in the lower portion of the dorsal region, that between the seventh and tenth segments inclusive, the column of Clarke has increased so considerably that it narrows and depresses the anterior extremity of the posterior columns, with the result that this becomes narrower and more pointed, and the outline traced from the middle line outwards to the gelatinous substance is concavo-convex.

If sections from the third to the sixth segment are compared with each other, certain criteria, insufficient for their absolute identification when examined by themselves, enable them to be placed in their order in the series. Thus the third dorsal approaches the form of the second by the large broad anterior extremity and the flat anterior surface of the posterior column. The remaining segments show simply a progressive narrowing of the anterior extremity and increasing obliquity of the anterior surface of the posterior columns. In the lower part of the dorsal region the progressive narrowing of the anterior extremity, pointing of the anterior surface, and increasing sinuosity of the outer surface of the posterior column, will indicate the serial order of the segments. The comparatively broad anterior extremities of the seventh and eighth segments will serve to distinguish them from the more acutely pointed ninth and tenth. The features which distinguish between these two segments are the broader posterior surface, and shorter median septum of the tenth segment.

The distinctive features of the first three cervical segments have not yet been considered. They will be fully noted in the description of the lower figures (Series B) in Plates I., II., and III., to which the reader is referred. The group of cells regarded as composing the nucleus of the spinal accessory nerve, however, forms a special feature, which requires notice. In the first segment it is situated behind and somewhat to the outer side of the anterior mesial group. In the second it is somewhat further back, but still not quite at the outer margin of the grey matter. In the third segment, however, it has reached the surface a little way behind the antero-lateral angle, and in the fourth (C. 4. b.) it has receded still further along the lateral margin. The nucleus has not been indicated at a lower level in the figures reproduced, although it has been traced as far as the sixth segment. It is possible that this remarkable change of position from the neighbourhood of the anterior mesial to that of the postero-lateral group may be related to the fact that the upper cells supply muscles of the palate, larynx, and the sterno-mastoid, while the lower cells supply the trapezius, a muscle which acts upon the upper extremity, the nerve cells for which have been seen to occupy the lateral group.

In conclusion, it is to be noted that the size of the motor cells in the various segments is by no means uniform. Those in the lumbo-sacral region are of greater size than those in the cervical region. Again, the cells in the first dorsal segment are smaller than those in the postero-lateral group of the eighth cervical. (In the upper figure of Plate X. the cells as represented appear probably somewhat smaller than they really are; but a careful comparison of the cells in the two sections from which Plates IX. and X. were reproduced, show that those in the first dorsal segment were undoubtedly of lesser size than those in the eighth cervical.) The cells in the dorsal region are smaller than those in either the cervical or lumbar region. It is probable that there is some relation between the size of the motor cell and that of the muscular fibre which it innervates. This would explain the reduction in small size of the cells in the first dorsal region, as compared with those in the cervical region. There appears to be almost no doubt that the first dorsal segment innervates the small intrinsic muscles of the hand, and that the remainder of the cervical enlargement supplies the longer muscles of the upper extremity. These in their turn are smaller than the muscles of the lower extremity, and accordingly the nerve cells which supply them are smaller than those in the lumbo-sacral region. For the same reason the small intercostal muscles are innervated by the small motor cells in the anterior cornu of the dorsal region.

LITERATURE.

The following papers may be referred to for further information bearing on the subject-matter of this work, and for the full bibliography which they contain.

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3. **Sano.** Journal de Neurologie et d'Hypnologie. 1897.
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5. **Collins.** New York Medical Record. 1894.
6. **Onuf.** Journal of Nervous and Mental Diseases. 1899.
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8. **Sherrington.** Philosophical Transactions. 1890.

PLATE I.

First Cervical Segment.

A

The cells in the anterior horn are arranged in three somewhat ill-defined groups :—

An anterior mesial group, at the extreme anterior limit of the cornu, consists of thirteen cells ;

A posterior mesial, behind and internal to the above, contains eight cells ;

An outer group, of slightly larger and more closely aggregated cells, sixteen in number, is the nucleus of the spinal accessory nerve.

B

The characteristics of the segment are :—

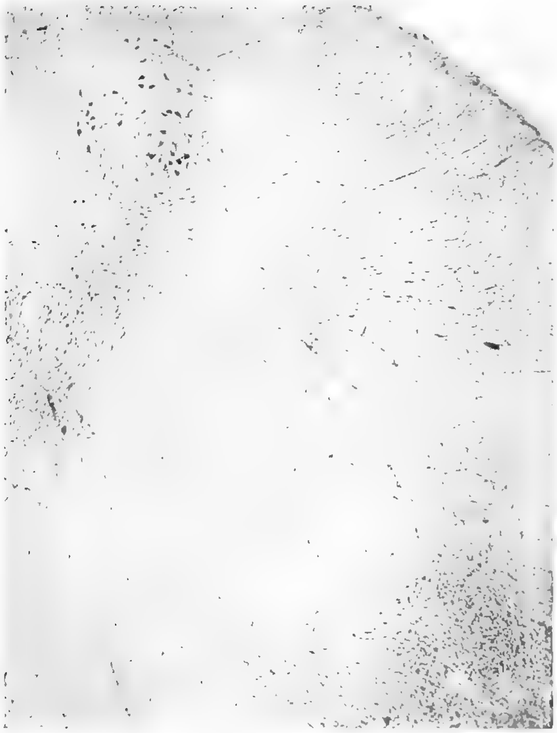
The club-shaped substantia gelatinosa Rolandi, and the long narrow neck of the posterior horn ;

The triangular outline and pointed anterior extremity of the posterior columns ;

The breadth of the posterior commissure ;

The prominent formatio reticularis between the anterior and posterior cornua ;

A faintly stained triangular area at the periphery of the lateral column, on a level with the tip of the anterior cornu, representing Helweg's triangle. (On the right side, its position is indicated by a slight depression of the surface.)



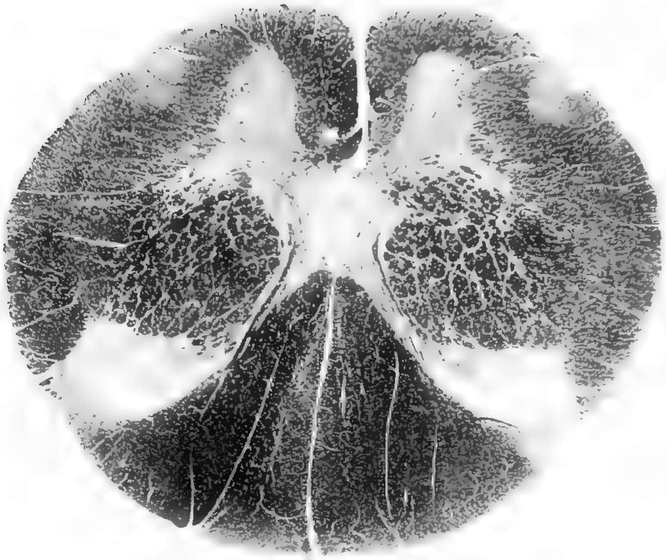


PLATE II.

Second Cervical Segment.

A

The anterior mesial group consists of twelve scattered cells.

The accessorius nucleus, consisting of eight cells, is situated near the middle of the anterior horn.

A group of very small cells, resembling those of the intermedio-lateral group of the dorsal region, is seen in the postero-lateral angle of the posterior horn.

B

The substantia gelatinosa has become more attenuated than in C. 1, though it is still club-shaped.

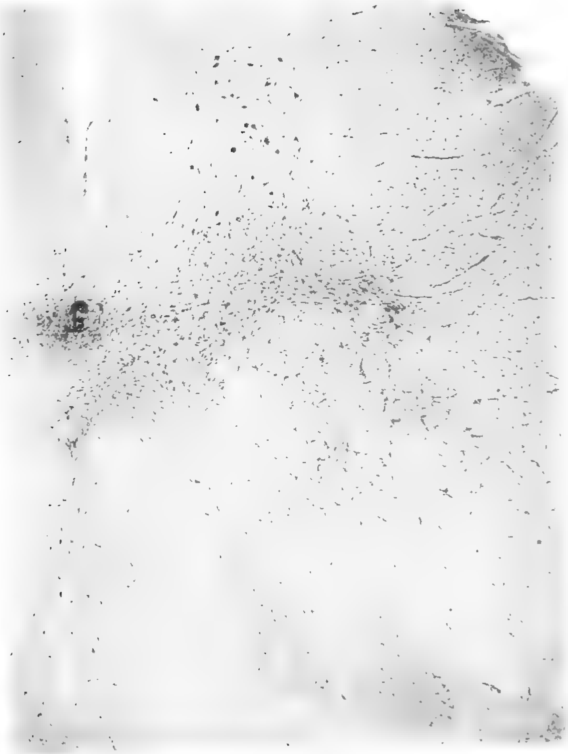
The apex of the area formed by the posterior columns is somewhat blunted.

The posterior commissure remains broader than the anterior.

The formatio reticularis is smaller than in C. 1, and on the left side it is traversed obliquely by the root of the spinal accessory nerve, which appears at the base of the anterior horn.

Helweg's triangle appears as the paler area at the periphery of the lateral column opposite the anterior cornu (marked on the right side by a linear depression of the surface).

The pale zone between the substantia gelatinosa and the periphery represents the lower extremity of the inferior root of the fifth nerve.



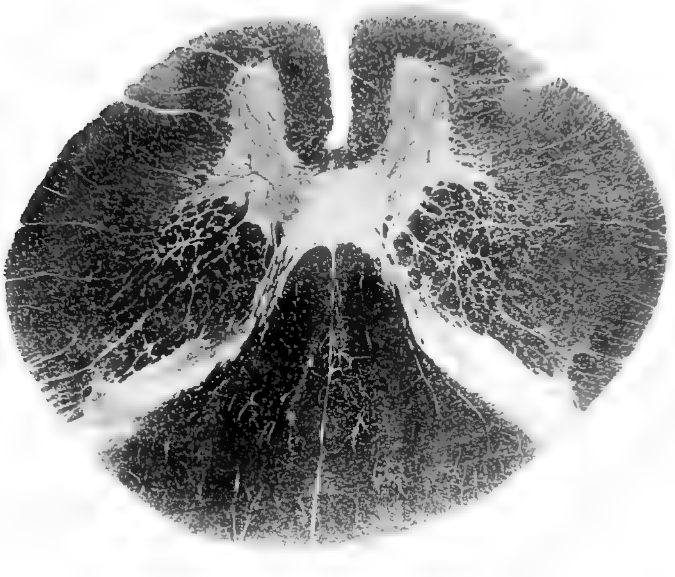


PLATE III.

Third Cervical Segment.

A

The anterior mesial group near the tip of the horn consists of twelve cells.

The accessorius group, near the lateral margin of the horn, consists of five cells.

A few smaller cells are seen near the postero-lateral angle of the horn.

B

The anterior cornu is pointed in front, and broad at its base.

It presents three angles and four surfaces.

The angles are termed *mesial*, *antero-lateral*, and *postero-lateral*.

The surfaces are *inner*, *anterior*, *antero-lateral*, and *posterior*.

The anterior surface is much shorter than the antero-lateral.

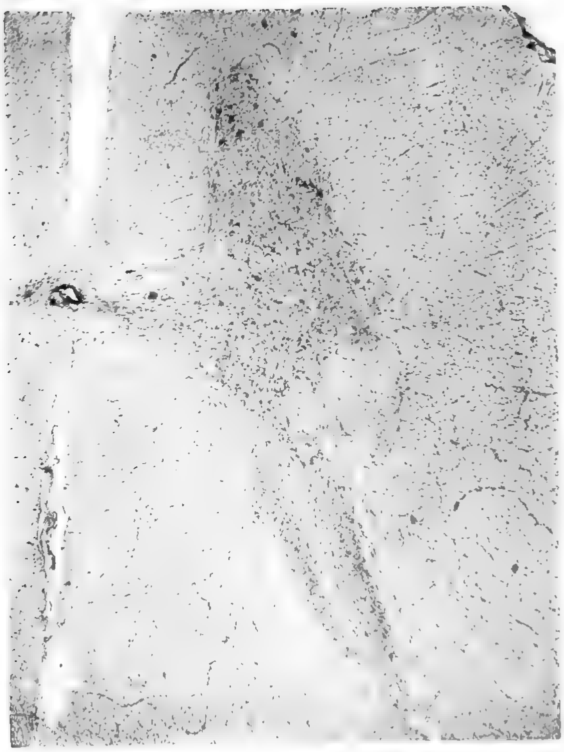
The substantia gelatinosa is no longer club-shaped; it has the form of a spear-head.

The area of the posterior columns is rounded anteriorly.

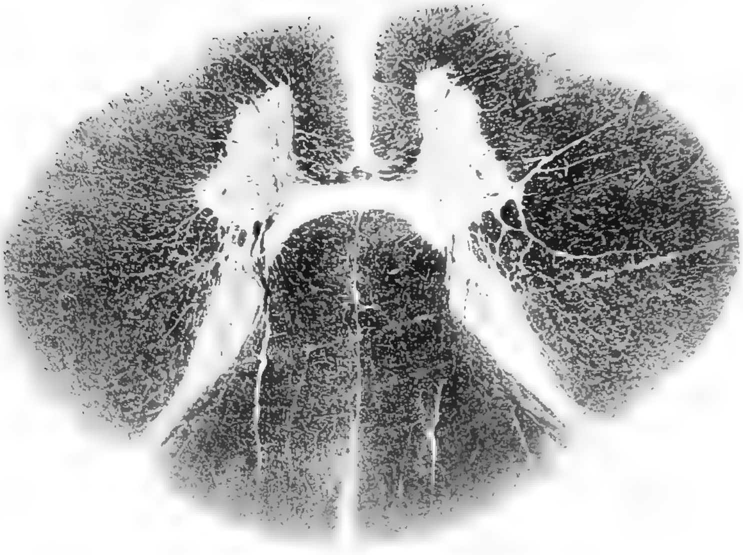
The breadth of the posterior commissure is reduced to twice that of the anterior commissure.

The formatio reticularis is greatly diminished in area.

Helweg's triangle is represented by the faintly stained area at the anterior periphery of the lateral column (marked on the right by a slight depression of the surface).



C 3



C 3

PLATE IV.

Fourth Cervical Segment.

A

C. 4. a.—(Upper part of Segment).

The anterior mesial group of cells near the tip of the anterior horn contains ten cells ;

Behind and slightly external to it is a compact group of seventeen cells (which probably represent the nucleus of the phrenic nerve).

Some cells of larger size lie more widely scattered near the postero-lateral angle of the horn.

C. 4. b.—(Lower part of Segment).

The anterior mesial group is composed of six cells.

The group immediately behind and external to it contains eighteen cells.

Six cells at the antero-lateral angle indicate the commencement of the antero-lateral group of cells which becomes so well developed in C. 5.

A group of seven cells close together, and lying slightly behind the antero-lateral angle, belongs to the accessorius nucleus.

Four cells at the postero-lateral angle indicate the upper limit of the postero-lateral group of motor cells.

B

The anterior cornu much enlarged and broadened. Its various margins are nearly equal in length.

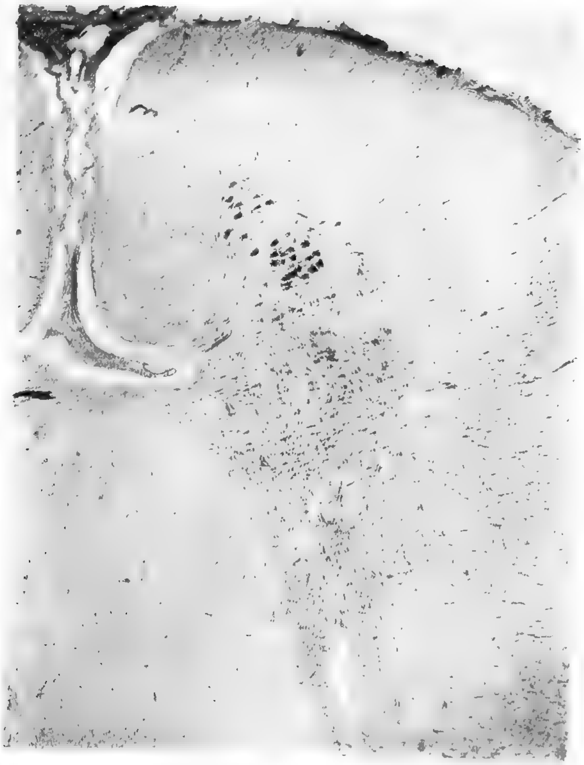
The anterior extremity of the posterior columns is flattened.

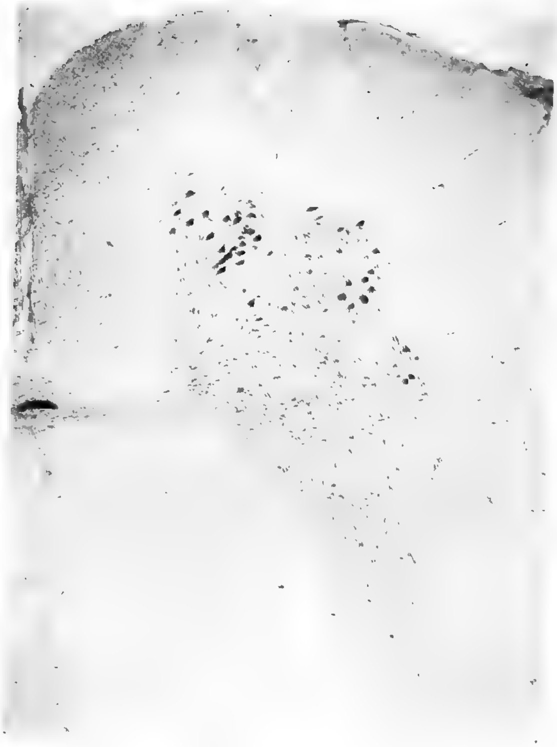
The posterior columns have greatly increased in area.

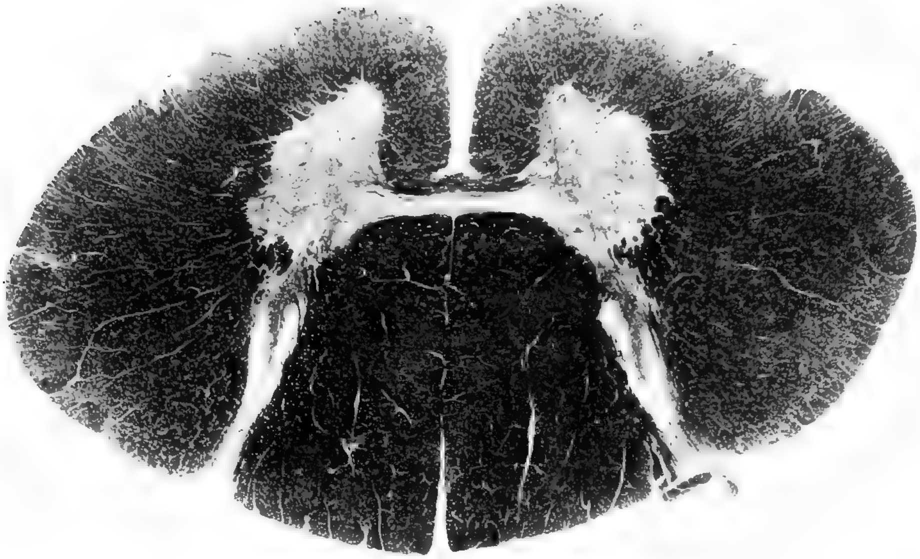
The posterior and anterior commissures are of equal breadth.

The gelatinous substance is further attenuated, is lancet-shaped, and further retracted from the periphery.

Helweg's triangle is less distinctly indicated than in C. 3.







C.4.

PLATE V.

Fifth Cervical Segment.

A

The anterior mesial group consists of fifteen cells.

It is separated by a wide interval, almost destitute of cells, from the antero-lateral group of twenty-seven cells.

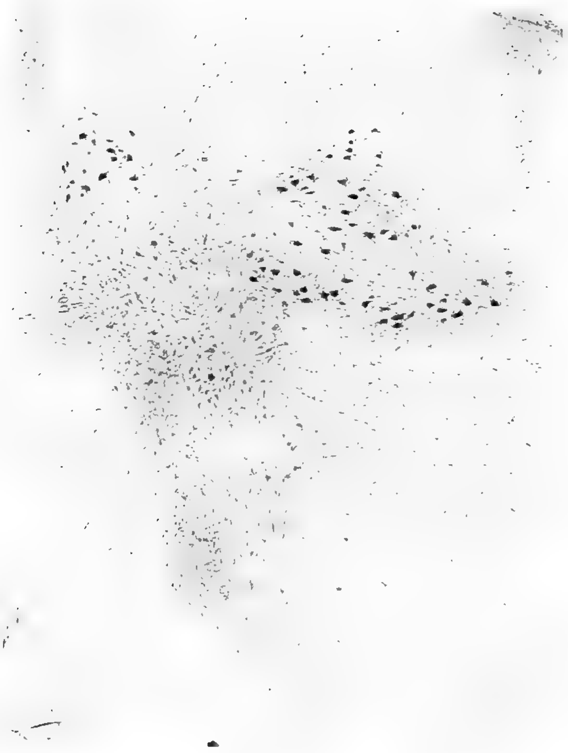
The postero-lateral group, which is much elongated transversely, and separated from the preceding by a narrow interval, has increased to thirty-one cells.

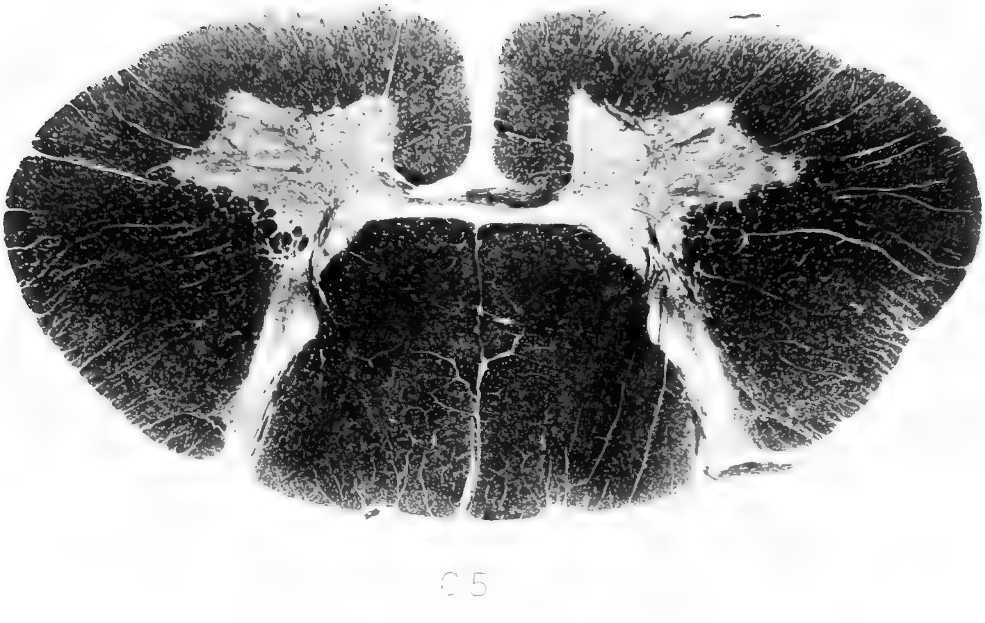
Several irregular groups of small cells are seen at the base of the anterior cornu.

B

The characteristic form of the anterior cornu of this segment is produced by concave anterior and antero-lateral margins, with pointed mesial, antero-lateral, and postero-lateral angles.

In the inner part of the horn is an area resembling in shape the anterior cornu of C. 3. It is paler than the outer portion, owing to its containing fewer medullated fibres.





C 5

PLATE VI.

Sixth Cervical Segment.

A

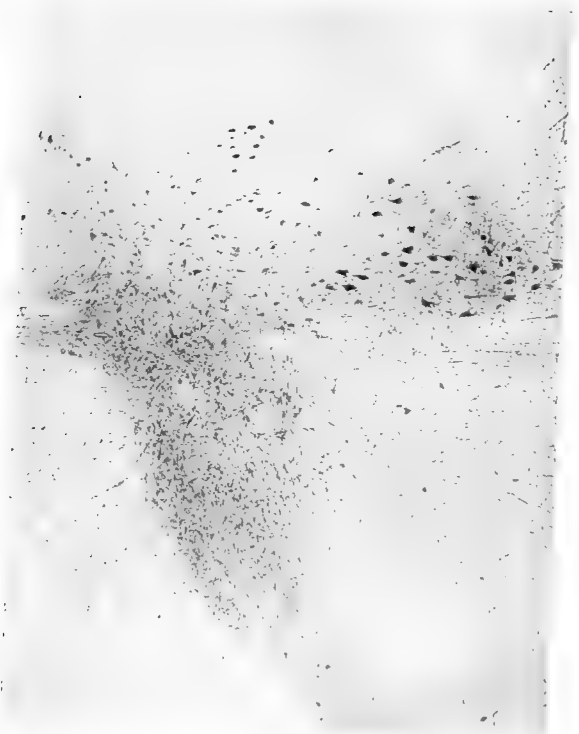
The anterior mesial group contains nine cells.

The posterior mesial group consists of five cells of smaller size.

The (upper) antero-lateral group, separated from the anterior mesial by a distinct interval, consists of eleven cells, which appear smaller than the majority of those in the postero-lateral group. The postero-lateral group, as appears more distinctly in the right anterior cornu of the lower figure, really consists of two parts, of which the larger and posterior consists of twenty-eight cells, and the smaller and anterior consists of seven somewhat scattered cells. (This latter group is the upper end of the antero-lateral group seen in C. 7.)

B

The anterior cornu differs in form from that of C. 5, by the inward displacement and flattening of the antero-lateral angle, and by the outward displacement and rounding of the postero-lateral angle. The antero-lateral margin has become convex forward, owing to the interpolation of a group of cells between the antero-lateral and postero-lateral groups. On the right side this group has produced a second antero-lateral angle.



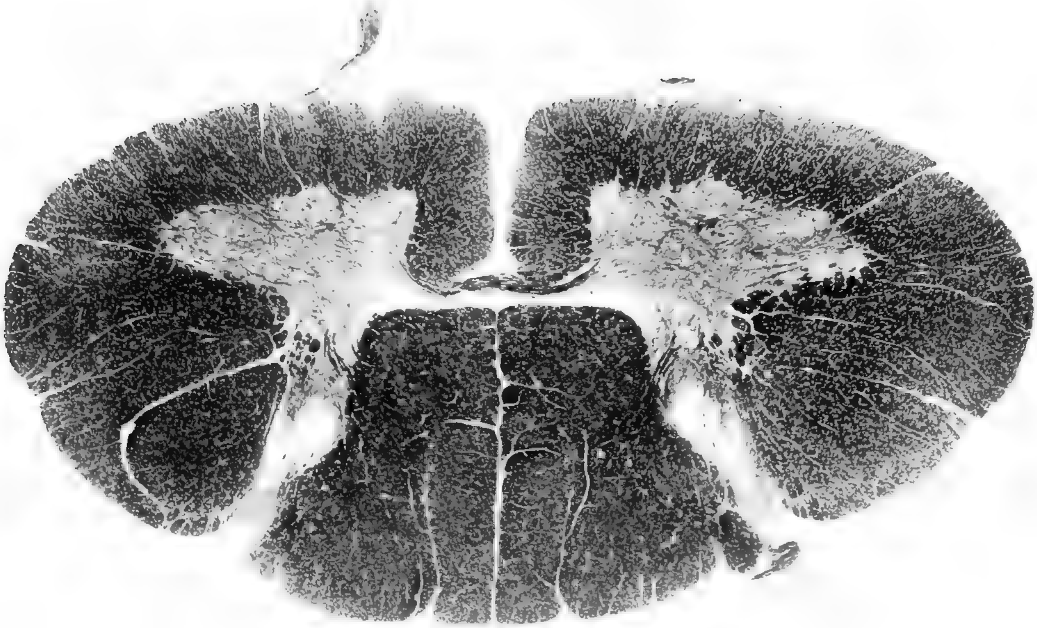


PLATE VII.

Seventh Cervical Segment.

A

The anterior mesial group consists of four cells.

The posterior mesial group consists of five cells of small size.

The (lower) antero-lateral group here attains its maximum number of thirty-five cells.

The postero-lateral group consists of sixteen cells.

An irregular group of smaller cells, along with one large multipolar cell, is seen at the junction of the anterior and posterior horns.

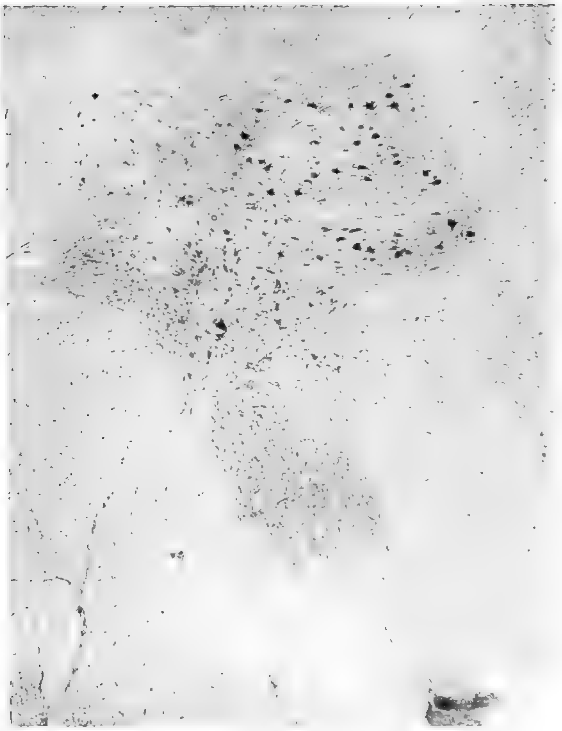
B

The almost rhomboidal outline of the anterior cornu, which is characteristic of this segment, is well seen.

The antero-lateral angle is further from, and the postero-lateral angle nearer the middle line than in C. 6. In consequence, the anterior margin is longer and the posterior margin shorter than in C. 6.

The prominent antero-lateral angle with its corresponding group of cells has developed out of the interpolated group of C. 6, while the antero-lateral angle of C. 5 with its group of cells has disappeared.

It is to be noted that the inner part of the anterior cornu is paler, *i.e.*, contains much fewer fibres than does the outer part.



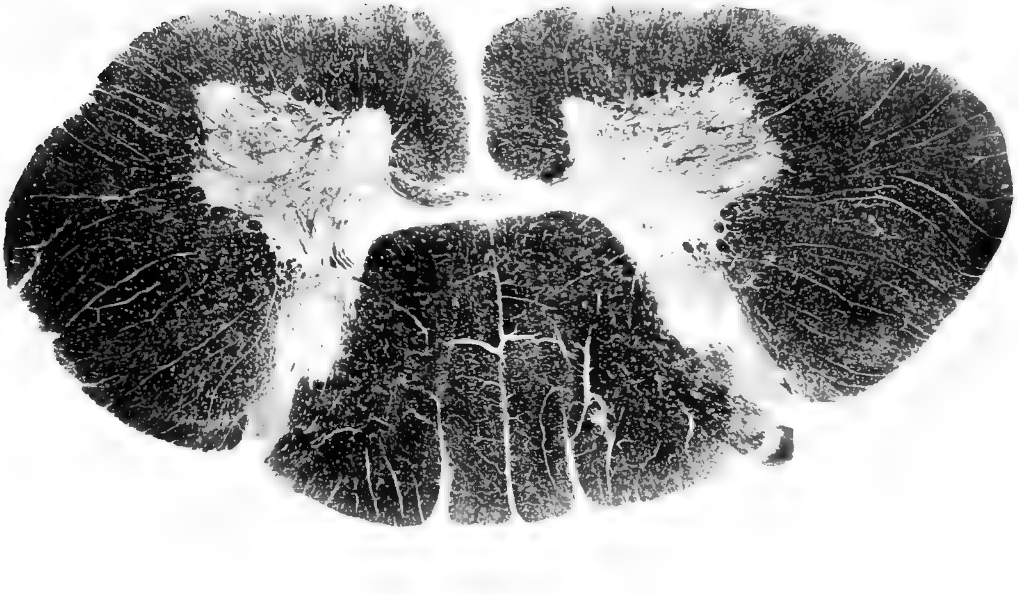


PLATE VIII.

Eighth Cervical Segment

(UPPER PART).

A

The anterior mesial group consists of four cells.

The posterior mesial is not represented.

The antero-lateral and postero-lateral groups are more sharply differentiated than in any other segment.

The (lower) antero-lateral group contains twenty-nine cells. Eleven of these are concentrated into an apparently distinct group at the posterior part of the main group, and consist of larger and more deeply stained cells.

The postero-lateral group consists of thirty cells, and shows a tendency to division into an inner group consisting of sixteen cells, and an outer group consisting of fourteen cells.

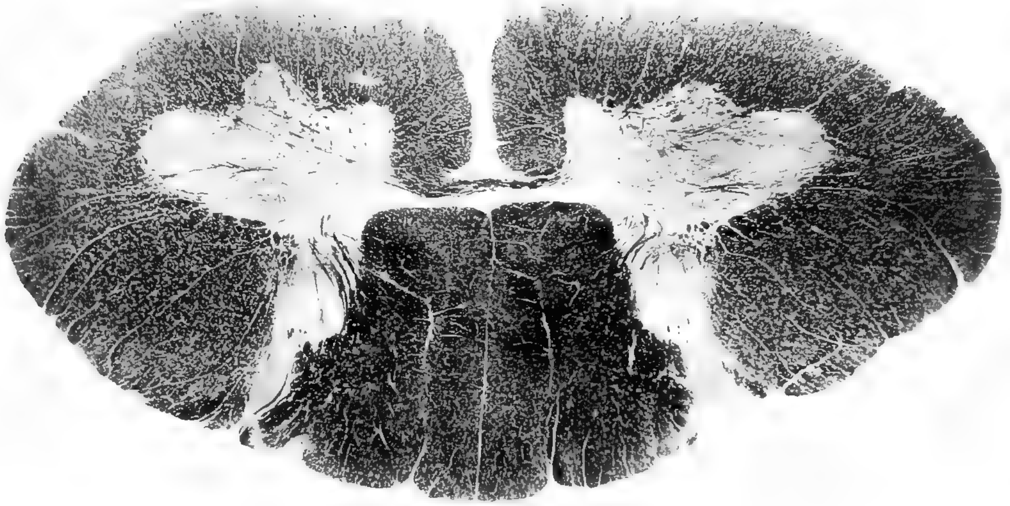
Behind there is a post-postero-lateral group of three cells.

B

Compared with C. 7, the anterior horn has lost its rhomboidal outline. The antero-lateral angle is displaced inwards so as to form an anterior projection about mid-way between the mesial and postero-lateral angles.

The latter has extended outwards and forwards so as to be almost on a level with the inner angle. The anterior and antero-lateral margins are both concave forwards, and the posterior margin convex backwards and outwards. Compared with C. 7, the posterior margin is greatly elongated.

The prominence, position, and rounded point of the antero-lateral angle are characteristic of the upper part of the eighth segment.



C 8 a

PLATE IX.

Eighth Cervical Segment

(LOWER PART).

A

The anterior mesial group is represented by seven cells.

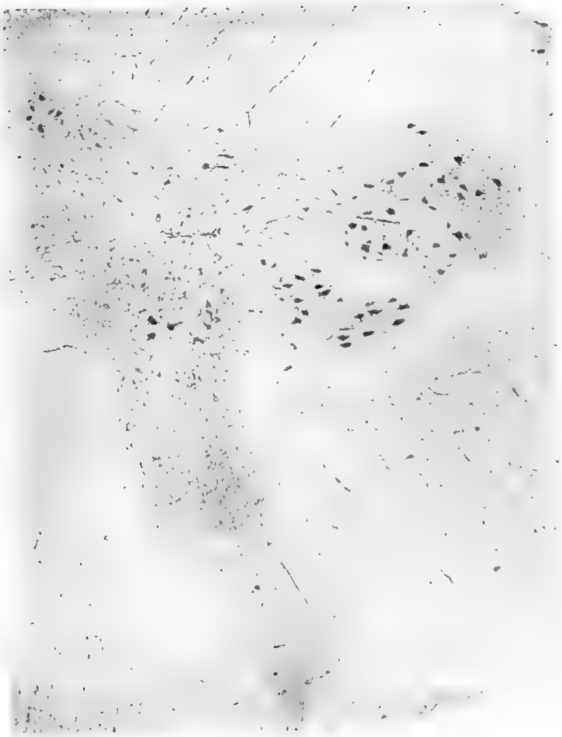
The antero-lateral group has disappeared.

The postero-lateral group consists of thirty-one cells.

Behind it, and separated by a space containing a blood-vessel, is the post-postero-lateral group, consisting of twenty-one cells.

B

The anterior cornu has become cup-shaped,—a long anterior concavity being produced by the disappearance of the antero-lateral angle from its position as seen in Pl. viii., and the fusion into a single long curve of the anterior and antero-lateral concave margins.



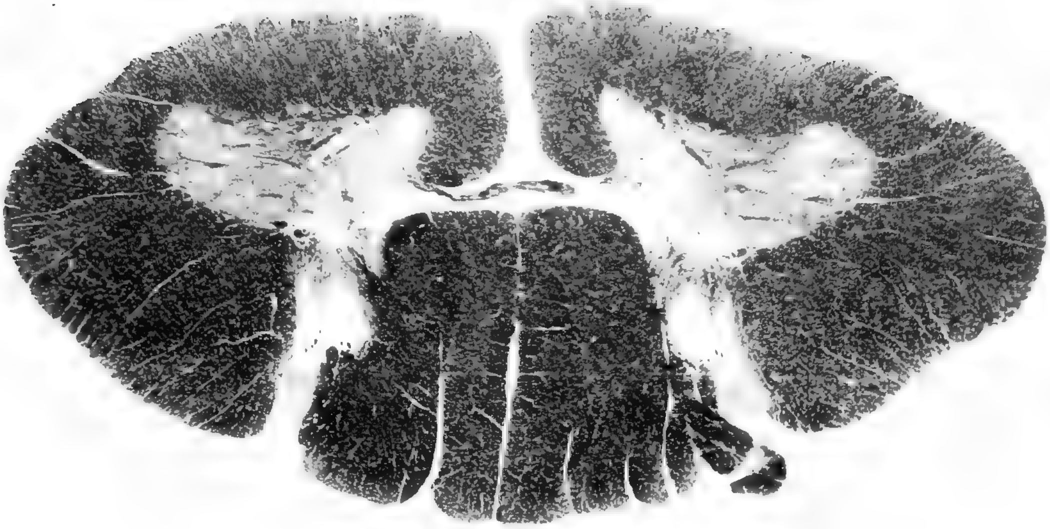


PLATE X.

First Dorsal Segment.

A

The anterior mesial group consists of seven cells.

The antero-lateral and postero-lateral groups are unrepresented.

The post-postero-lateral group consists of twenty-eight cells, which are distinctly smaller than those in the corresponding part of the lower cervical segments.

A small group of five cells is situated at a slight distance to the inner side of the post-postero-lateral group.

The intermedio-lateral group on its outer side consists of thirteen very small cells.

There are numerous small cells scattered very irregularly through the inner part of the anterior horn.

B

The anterior cornu differs from that of C. 8 in the recession of the postero-lateral angle, so that while the united anterior and antero-lateral margins still form a concave outline, the cup shape is no longer present.

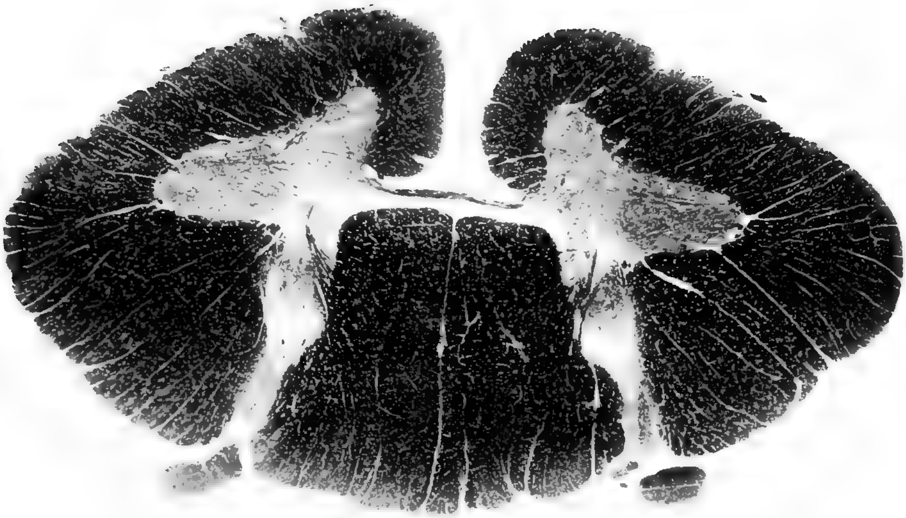


PLATE XI.

Second Dorsal Segment.

A

The anterior mesial group contains six small cells.

The posterior mesial group contains five small cells.

The antero-lateral group has five cells, also of small size.

The postero-lateral and post-postero-lateral groups are not represented.

The intermedio-lateral group, at the postero-lateral angle, contains fourteen small deeply-stained cells, very closely aggregated.

The column of Clarke, on the inner side of the base of the posterior horn, contains three cells.

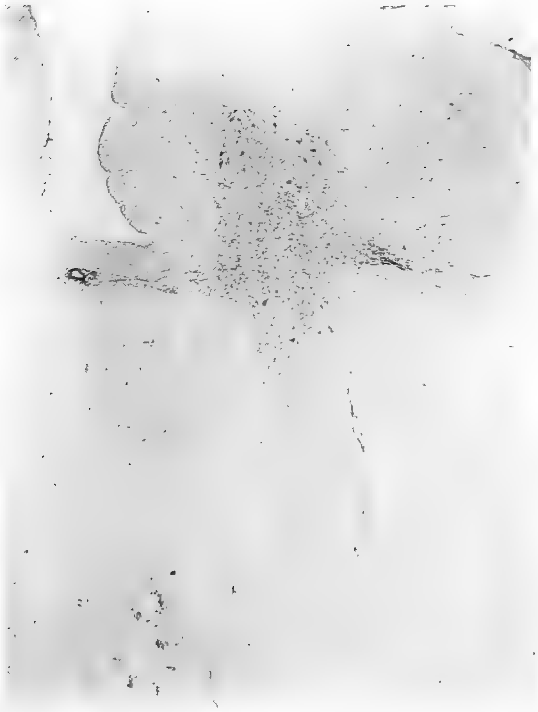
B

The anterior cornu is greatly diminished in size, its broad, sloping postero-lateral projection being replaced by a short sharply-pointed angle.

An obtuse antero-lateral angle is present behind the plane of the anterior mesial angle.

The posterior horn is distinctly narrower than in D. I.

The anterior margin of the posterior columns is almost a straight line.



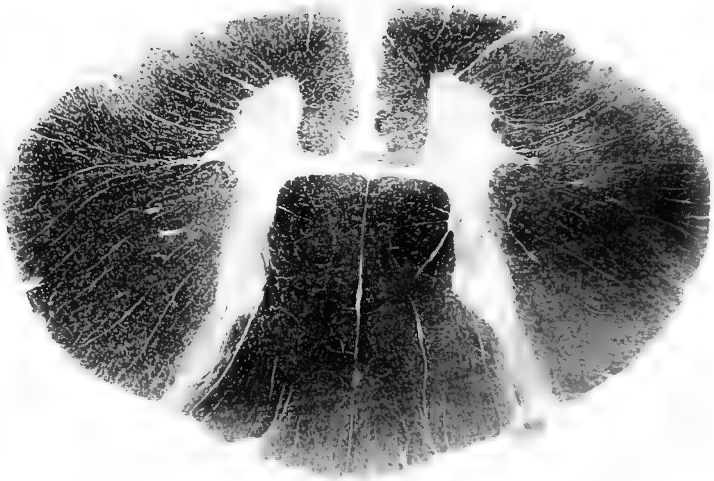


PLATE XII.

Third Dorsal Segment.

A

The anterior mesial group, no longer distinct from the antero-lateral, consists of six cells.

The postero-mesial group consists of sixteen cells of still smaller size.

The intermedio-lateral group consists of eighteen cells, some of which are situated among the white fibres, external to the postero-lateral angle.

Clarke's column has five cells.

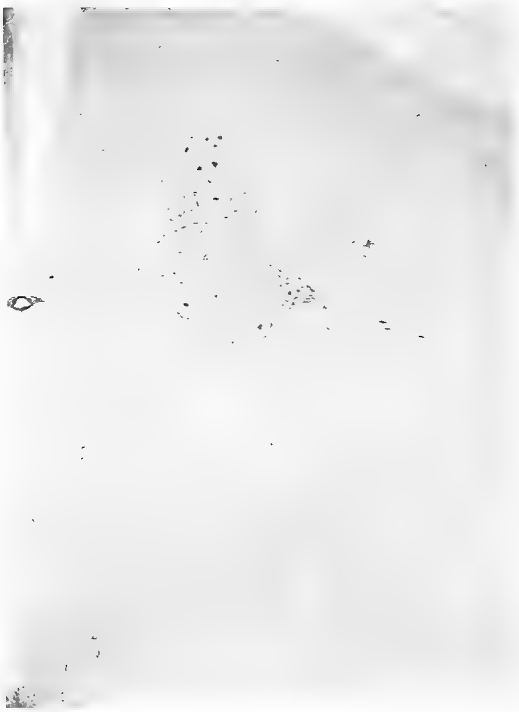
B

In the anterior cornu the antero-lateral angle has advanced so that the head of the cornu is becoming flattened, especially on the right side, which represents a slightly lower level than the left.

The postero-lateral angle is less prominent on the right side.

Clarke's column is more evident and encroaches on the antero-external margin of the sectional area of the posterior columns.

The flat anterior extremity of the posterior columns is to be noted.



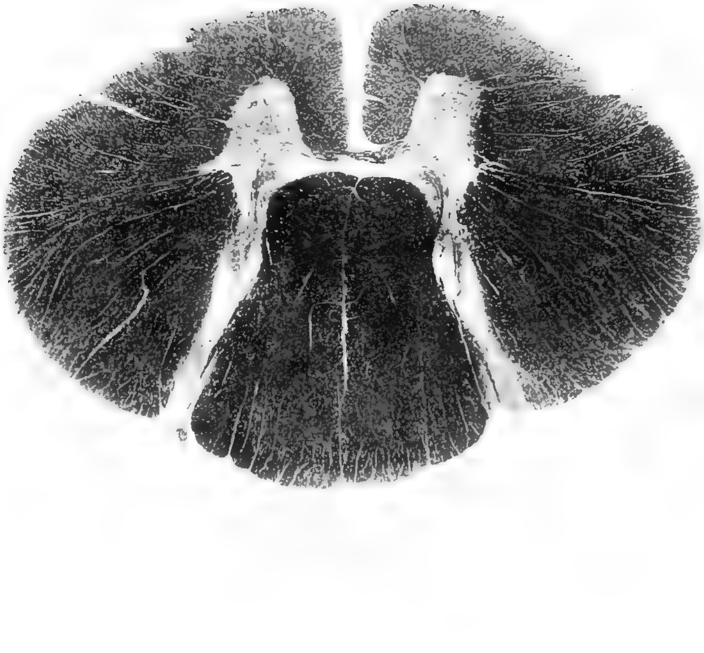


PLATE XIII.

Fourth Dorsal Segment.

A

The anterior mesial group contains seven cells.

The postero-mesial group contains seven cells.

The intermedio-lateral group consists of eight cells.

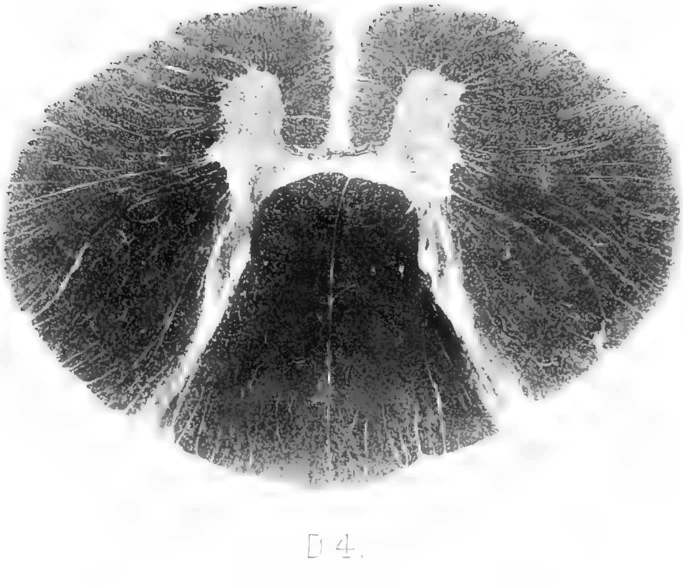
B

The anterior horn closely resembles in form and size that of the right side of D. 3.

The column of Clarke is slightly more prominent, so that the transverse outline of the anterior surface of the posterior columns becomes slightly oblique.

The posterior horn is sharply pointed, and differs in no essential respect from that of D. 3.

Pl. II.



D 4.

PLATE XIV.

Fifth Dorsal Segment.

A

The anterior mesial group contains nine cells.

The posterior mesial group contains two cells.

The intermedio-lateral tract contains twenty cells.

The column of Clarke contains eight cells.

B

Compared with D. 4, the anterior cornu is narrower and its postero-lateral angle somewhat less pointed.

The anterior surface of the posterior columns also shows an increasing obliquity.

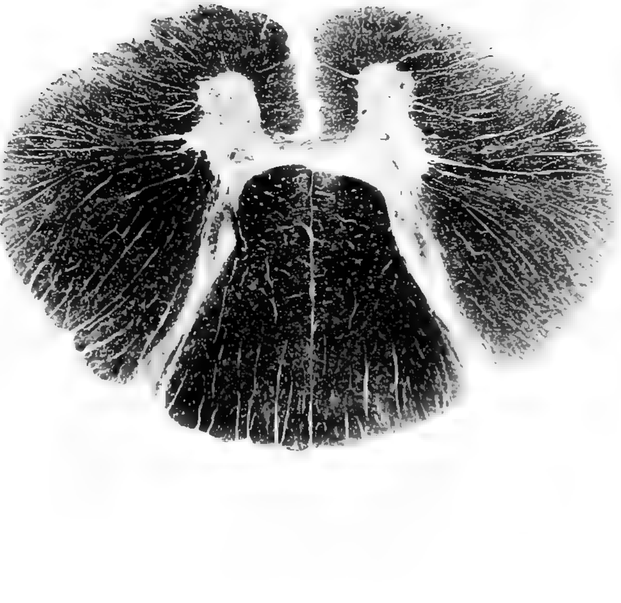


PLATE XV.

Sixth Dorsal Segment.

A

The anterior mesial group contains nine cells.

The posterior mesial group contains four cells.

The intermedio-lateral group contains twelve cells.

The column of Clarke contains ten cells.

B

The form of the anterior and posterior horns remains practically unchanged.

The anterior margin of the posterior column shows a further increase in its obliquity, owing to the presence of the column of Clarke. The outline is convex from the middle line to the substantia gelatinosa.

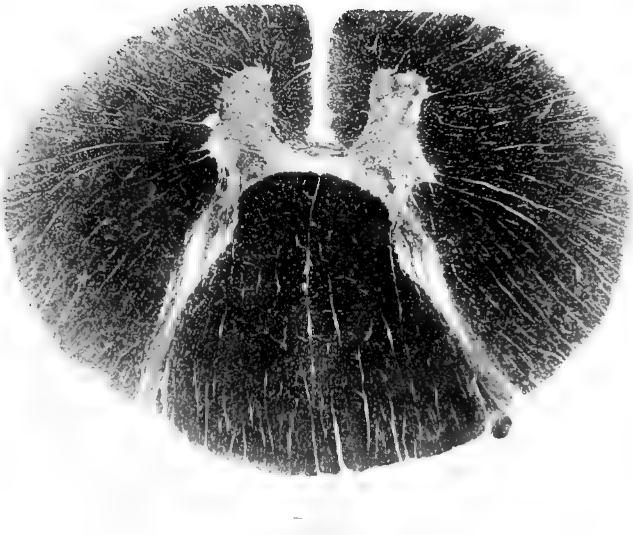


PLATE XVI.

Seventh Dorsal Segment.

A

The anterior mesial group contains nine cells.

The posterior mesial group contains seven cells.

The intermedio-lateral group contains eight cells.

Clarke's column contains four cells.

B

The anterior cornu is very narrow and concave on its outer surface.

The column of Clarke has enlarged still further so as to depress the outer angle of the anterior part of the posterior column, and to give this a sinuous outline.

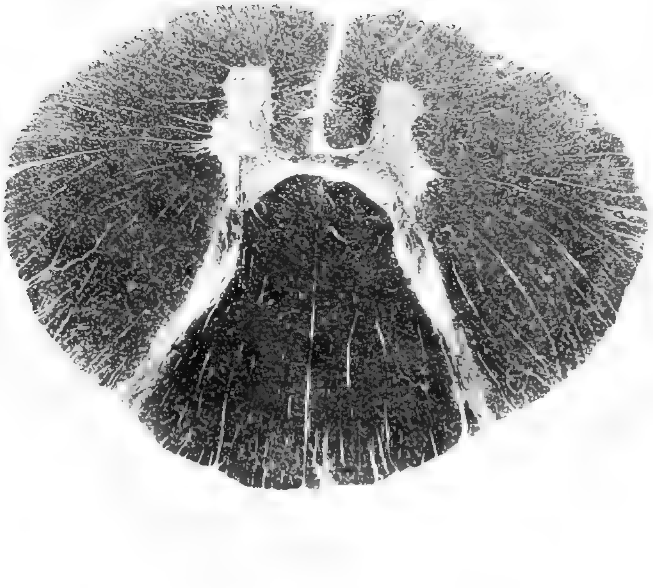


PLATE XVII.

Eighth Dorsal Segment.

A

The anterior mesial group contains eleven cells.

The posterior mesial group contains six cells.

The intermedio-lateral group contains twelve cells.

The column of Clarke shows fourteen cells.

B

The outline of the anterior cornua shows no material difference from C. 7, except that the antero-lateral margin is less concave.

The columns of Clarke, considerably increased in size, impinge further on the posterior columns, the anterior extremity of which is greatly narrowed and its outline from the middle line to the gelatinous substance more sinuous than in D. 7.

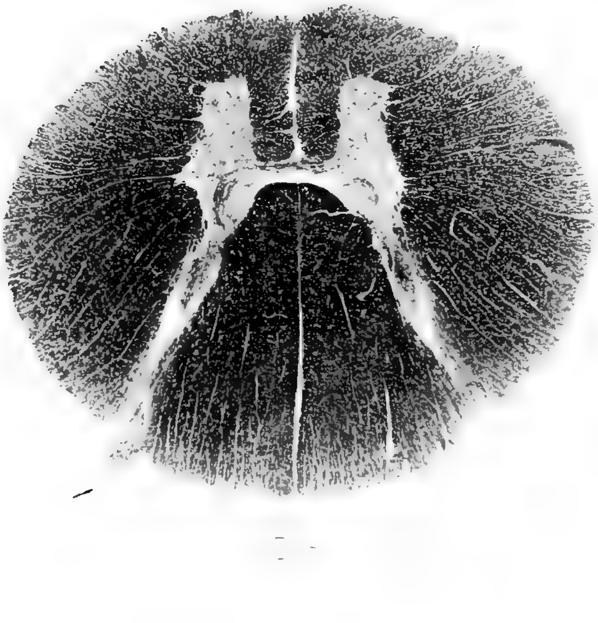


PLATE XVIII.

Ninth Dorsal Segment.

A

The anterior mesial group consists of fifteen cells.

The posterior mesial group contains six cells.

The intermedio-lateral tract contains nineteen cells.

The column of Clarke contains ten cells.

B

The anterior cornu has a flat or slightly rounded head.

The base of the horn on the left side of the section has increased in breadth.

The posterior columns are more pointed anteriorly, owing to the increasing encroachment upon them of the larger column of Clarke.

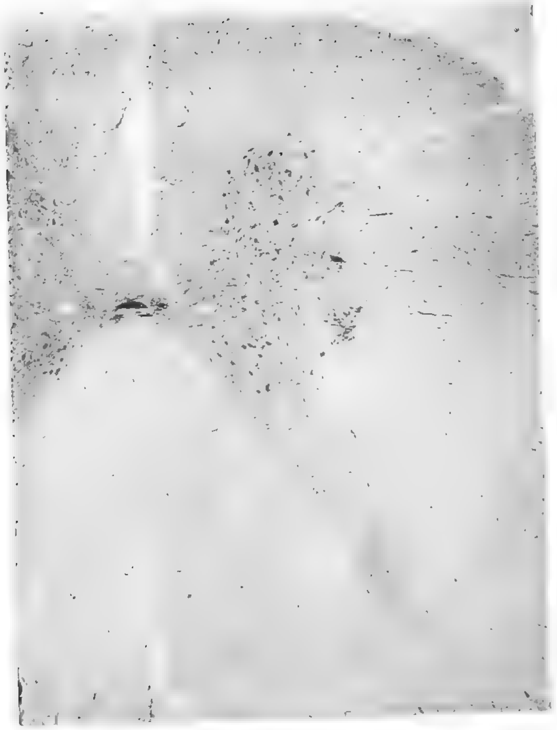


PLATE XIX.

Tenth Dorsal Segment.

A

The anterior mesial group contains five cells.

The posterior mesial group contains five cells.

The intermedio-lateral group contains seventeen cells.

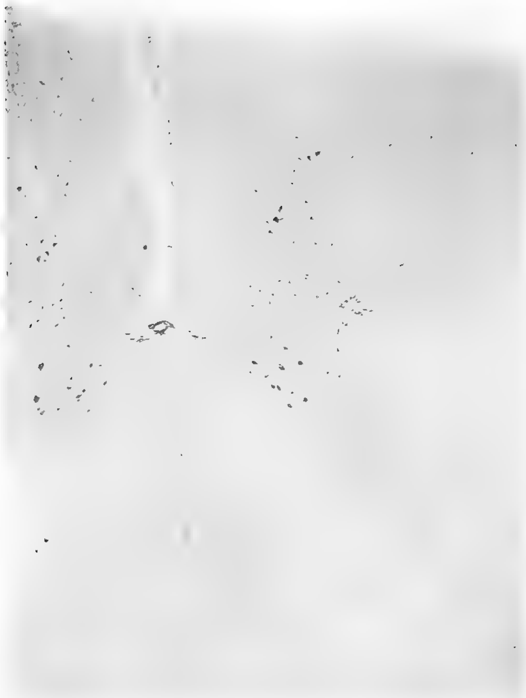
The column of Clarke contains ten cells.

B

The anterior cornu is narrower than that of D. 9. Its inner and antero-lateral margins are parallel with each other and with the anterior median fissure.

The posterior columns are pointed anteriorly, and their margins sinuous.

The posterior horns are broader, and inclined to each other at a wider angle than in D. 9.



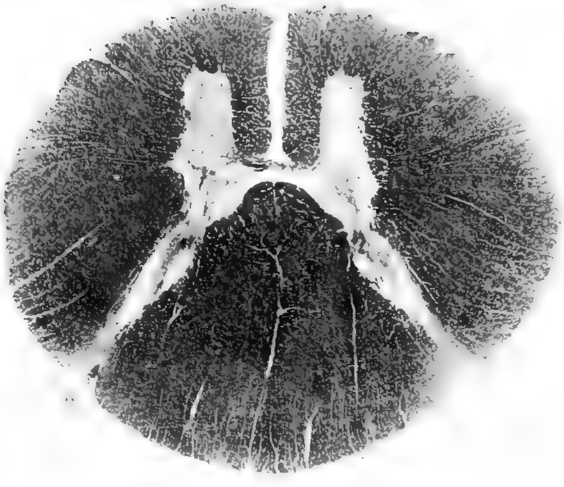


PLATE XX.

Eleventh Dorsal Segment.

A

The anterior mesial group contains ten cells.

The posterior mesial group contains thirteen cells.

The intermedio-lateral group contains sixteen cells, some of which lie in the white matter adjacent to the postero-lateral angle.

The column of Clarke contains eleven cells.

B

The anterior cornu has increased slightly in size. Its inner and antero-lateral margins are almost parallel to each other.

The anterior mesial angle is on a plane anterior to the antero-lateral angle.

The columns of Clarke are still larger than in D. 10.

The posterior cornua have considerably increased in size, and show a distinct heel on their inner side.

The posterior column is very narrow in front, and sinuous in its outer margin.

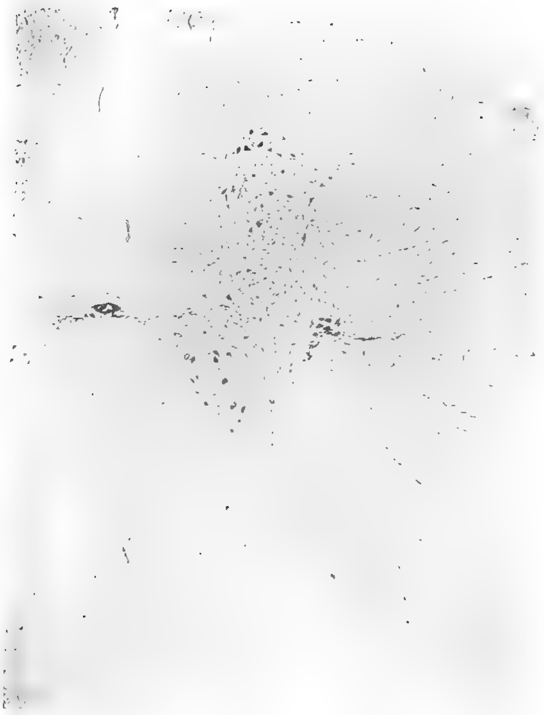


PLATE XXI.

Twelfth Dorsal Segment.

A

The anterior mesial group contains eight cells.

The posterior mesial group contains nine cells.

The antero-lateral (or anterior) group is indicated by three cells, at the antero-lateral angle.

The intermedio-lateral group consists of twenty cells, closely aggregated at the postero-lateral angle.

The cells of the column of Clarke are thirteen in number.

B

Both horns are considerably larger than in D. 11.

The antero-lateral margin is inclined slightly to the anterior median fissure.

The antero-lateral projection forms an obtuse angle.

The postero-lateral projection is a sharp point directed outwards and slightly backwards.

The column of Clarke has further increased, and projects further into the posterior column.

The posterior cornu is broader, still lancet shaped, with a distinct heel on its inner side.

The sinuosity of the outer margin of the posterior column is more marked than in any other section except L. 1.

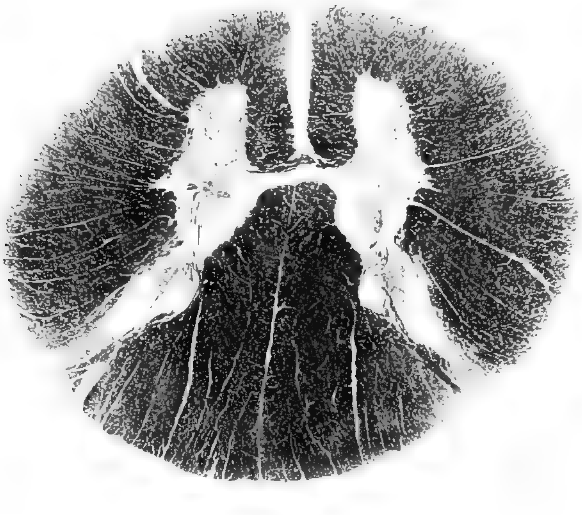


PLATE XXII.

First Lumbar Segment.

A

The anterior mesial group is represented by five cells of small size.

The posterior mesial group consists of three cells.

A group of three cells to the outer side of the anterior mesial may be termed anterior, as they differ in character from those found in the antero-lateral group at lower levels.

Ten cells of small size, closely aggregated, in the postero-lateral angle, belong to the intermedio-lateral column of cells.

Clarke's column consists here of ten cells. It is not found below this level.

An irregular group of fifteen very small cells, in front of Clarke's column, represents Stilling's nucleus.

B

The characteristic features of this segment are the oval form and prominence of Clarke's column; the pointed postero-lateral angle of the anterior cornu; the increasing width of the anterior and posterior cornua as compared with D. 12; and the narrow neck and lancet shape of the posterior cornu as compared with that of L. 2.

The margin between the antero-lateral and postero-lateral angles is formed by a straight line.

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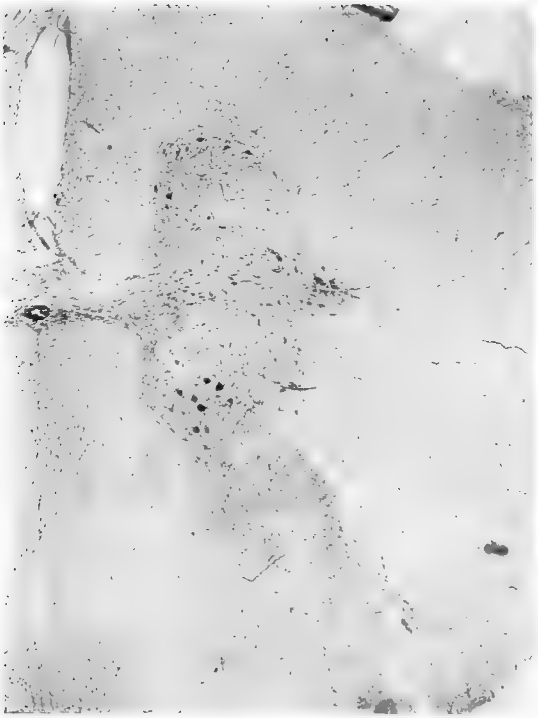

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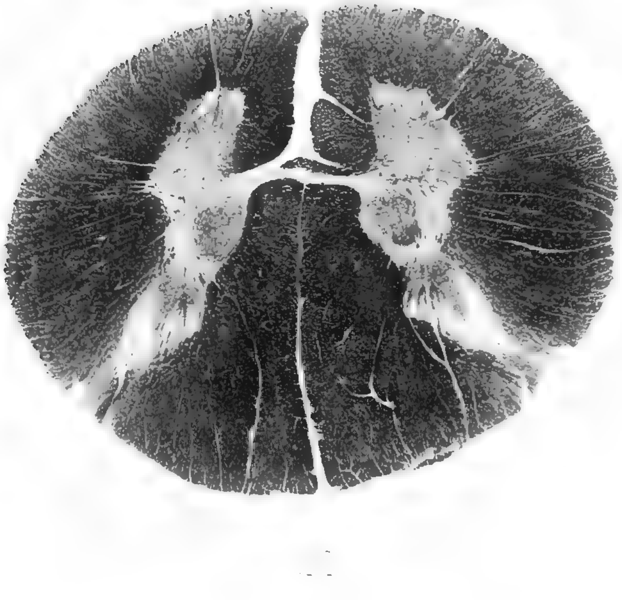

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PLATE XXIII.

Second Lumbar Segment.

A

The anterior mesial group is represented by seven cells.

A group of four cells, external to the above, seems to correspond to the anterior group of L. 1.

The antero-lateral group contains ten cells. It is situated in front and to the outer side of the postero-lateral group, which consists of twenty-six cells. These two groups are not very sharply separated from each other.

A group of three cells, slightly removed from the inner side of the postero-lateral group, may represent the upper limit of the central group, which becomes prominent in L. 3. The cells in the postero-lateral group are slightly larger than those in the antero-lateral.

The column of Clarke is no longer seen.

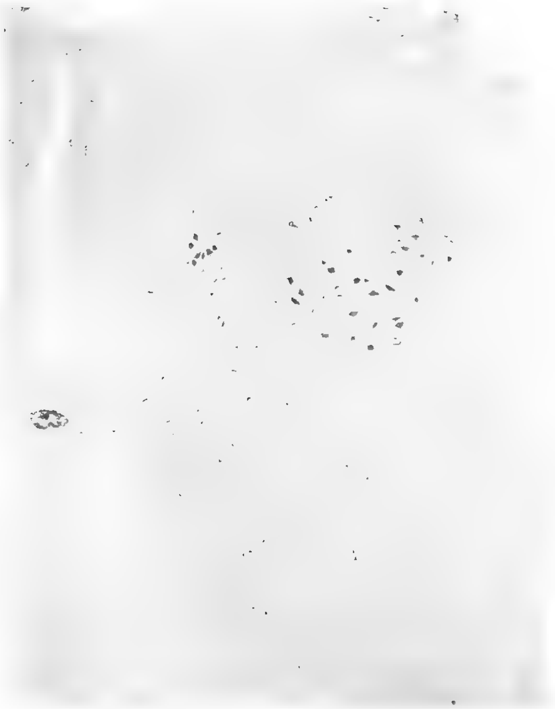
Irregular groups of very small cells are seen at the base of the anterior horn, presumably belonging in part to Stilling's nucleus.

B

The anterior horn differs from that of L. 1, by the superposition on its outer side of the large area with the rounded outer margin which contains the two lateral cell groups.

The posterior cornu has lost its narrow neck, and its gelatinous substance its lancet shape. Both have become broader than in L. 1.

The posterior columns are also altered in form, owing to the change in the posterior horn and the disappearance of Clarke's column.



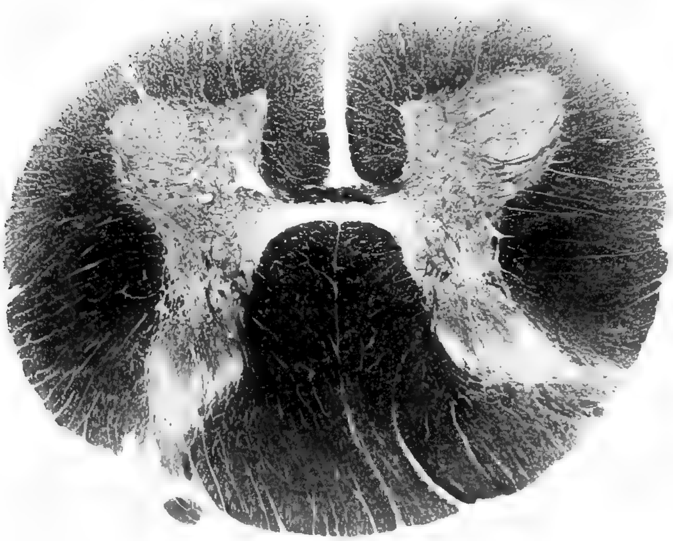


PLATE XXIV.

Third Lumbar Segment.

A

In the anterior mesial group there are five small cells. Slightly outside this lies the anterior group of four small cells.

The antero-lateral group consists of eight cells. It is separated by a distinct interval from the postero-lateral group, which is now greatly enlarged, and is represented by thirty-five large motor cells.

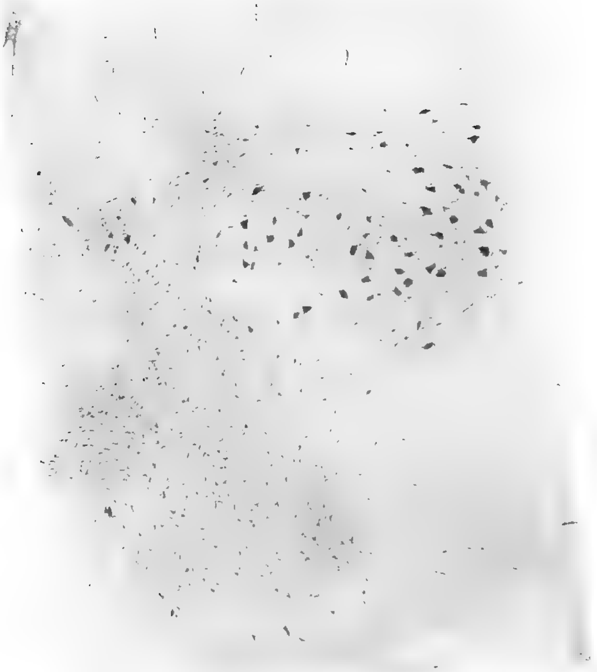
There is some indication of a division of this group into two parts, of which the outer contains eighteen, and the inner seventeen cells.

A central group, on the inner side of, and distinctly separated from, the postero-lateral group, contains twelve cells.

B

The anterior cornu differs from that of L. 2, mainly by its larger size, its more rounded mesial angle, and its convex anterior margin. The increase in width of the neck and of the amount of gelatinous substance is considerable.

Reflex collaterals are distinctly seen passing through the posterior horn towards the anterior.



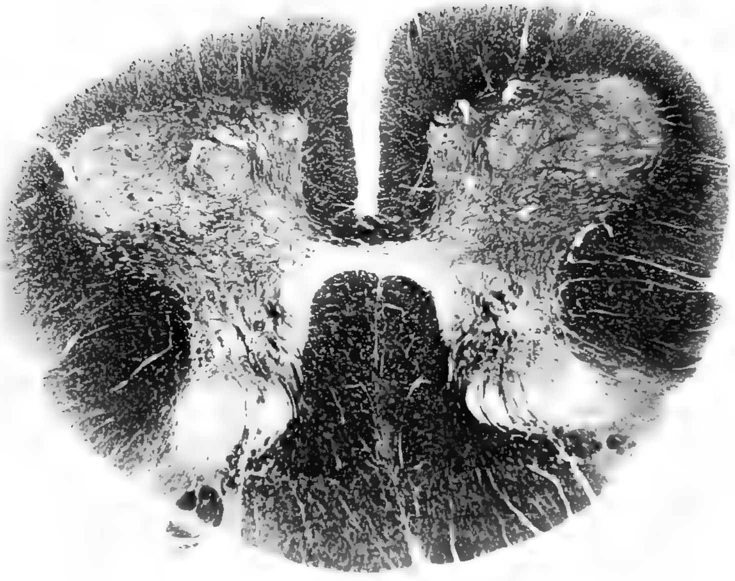


PLATE XXV.

Fourth Lumbar Segment.

A

The anterior mesial group consists of five or six cells of very small size. The anterior group seems to be represented by four very small cells.

The antero-lateral group is much larger than that in L. 3, and contains twenty-four cells. It is separated by a distinct interval from both the postero-lateral and central groups.

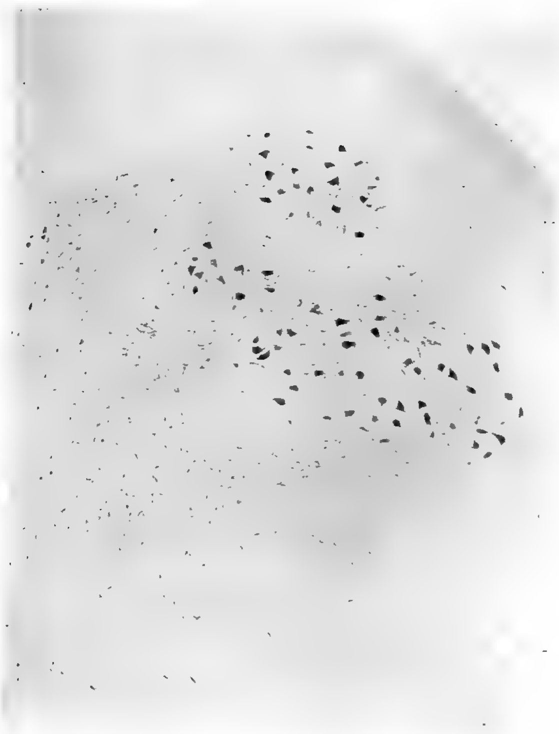
The postero-lateral group is represented by fifty cells, and shows some indication of further subdivision.

The central group is formed by an oval collection of eleven cells. It is internal and intermediate to the antero-lateral and postero-lateral groups.

B

The characteristic form is given to the anterior cornu of this segment by the rounded projections formed by the antero-lateral and postero-lateral cell groups, and by the rounding off of the anterior mesial angle.

The greater breadth of the posterior commissure, of the neck of the posterior horn and of its gelatinous substance is to be noted.



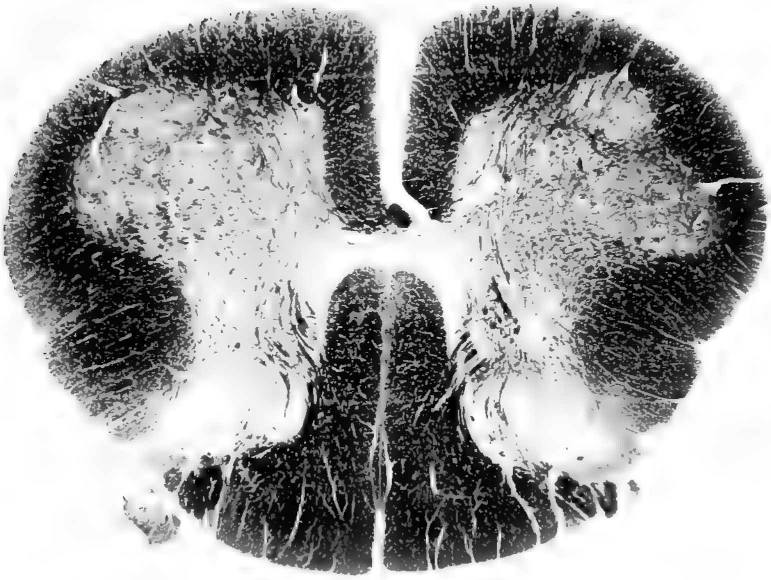


PLATE XXVI.

Fifth Lumbar Segment.

A

The anterior mesial group is unrepresented.

The antero-lateral group contains twenty-two cells.

The postero-lateral group, as in L. 4, consists of fifty cells.

The central group consists of eighteen cells.

B

The anterior cornu differs from that of L. 4, by the greater prominence of the antero-lateral and postero-lateral projections, and by the concavity between them which is hardly present in L. 4.

The postero-lateral mass of cells is displaced further backwards so that the angle formed by the anterior and posterior cornua is more acute than in L. 3.

The collateral fibres passing through the inner part of the posterior cornu mainly towards the antero-lateral group of cells is very clearly seen.

There is no marked change in the posterior cornua as compared with L. 4, except that their internal margins are more nearly parallel to each other.

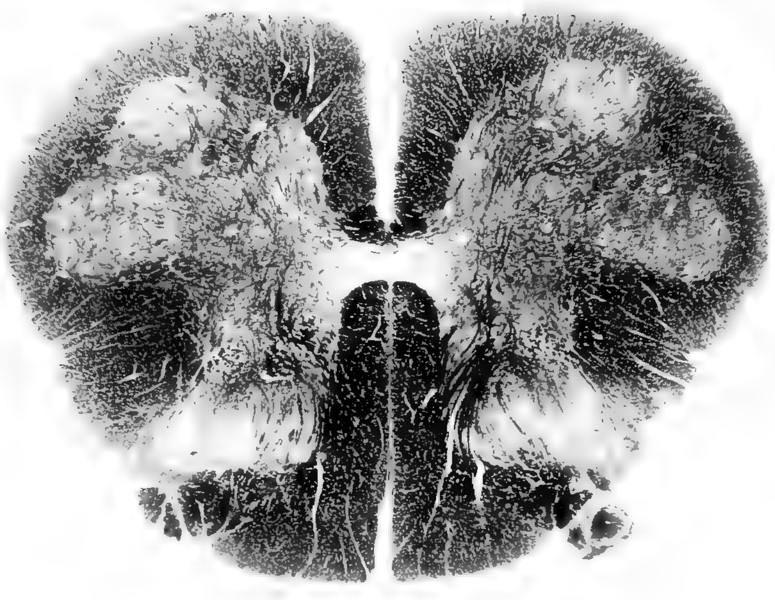


PLATE XXVII.

First Sacral Segment.

A

The antero-mesial group is unrepresented.

The antero-lateral group consists of thirty-three cells, and appears to be divisible into an inner portion consisting of eighteen, and an outer portion consisting of fifteen cells.

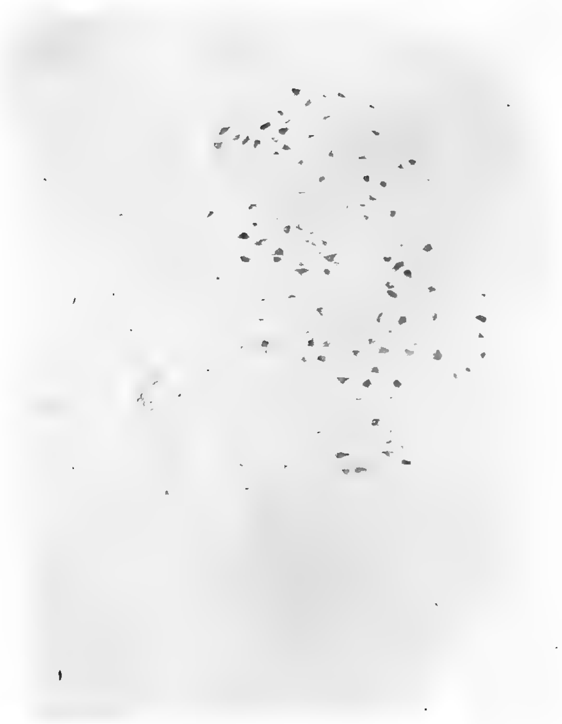
The postero-lateral group contains thirty-four cells, of which nine are arranged as an inner and twenty-five as an outer group. Behind the latter and slightly separated from it is a small group of seven cells,—the post-postero-lateral nucleus.

The central nucleus, distinctly separated from both antero-lateral and postero-lateral groups, consists of twenty cells.

B

In the anterior cornu the antero-lateral and postero-lateral projections are more closely approximated, so that the concavity between them, which is so marked in L. 5, tends to disappear. The postero-lateral projection is not directed so much backwards as in L. 5, and the angle between the anterior and posterior cornua is thus somewhat more obtuse. On the right side behind the main group of cells in the postero-lateral projection, can be seen three cells which belong to the post-postero-lateral group. They appear as pale points.

Reflex collaterals, in diminished number, pass mainly to the antero-lateral group of cells.



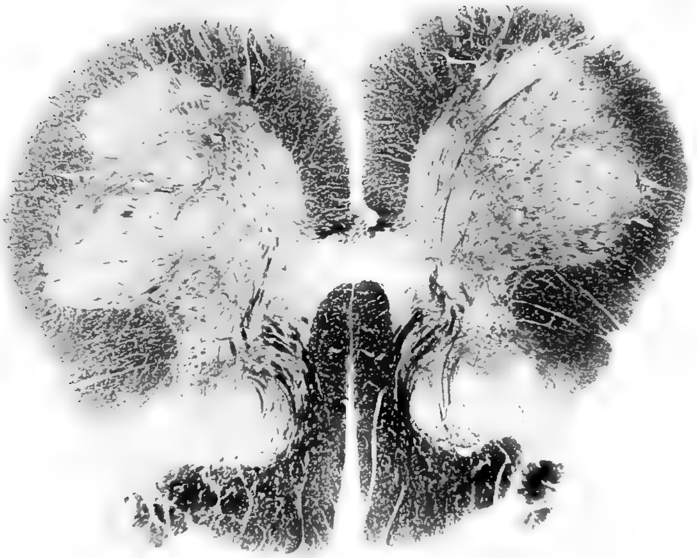


PLATE XXVIII.

Second Sacral Segment.

A

S. 2. a.—(Upper part of Segment).

The anterior mesial group is unrepresented.

The antero-lateral group consists of twenty cells, somewhat widely separated from each other and showing a tendency to divide into an outer and an inner group.

The postero-lateral group consists of thirty-one cells, of which eight form a small group internal to a large, closely compacted outer one of twenty-three cells.

The post-postero-lateral group consists of six cells. It is separated by a distinct interval from the postero-lateral group. In the central group there are eleven cells.

S. 2. b.—(Lower part of Segment).

There is one cell in the anterior mesial group.

The antero-lateral group contains nine cells. It is separated by a very slight interval from the postero-lateral group, which consists of twenty-two cells, and has advanced almost into the place occupied by the antero-lateral group in S. 2. a.

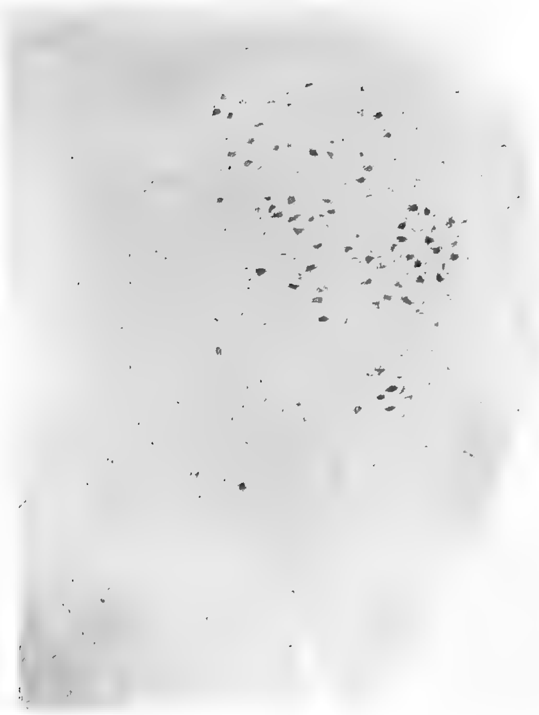
The post-postero-lateral group now more widely separated from the postero-lateral group has increased to twenty-five cells.

The central group has disappeared.

B

The anterior cornu has undergone a remarkable change of form, which can be best understood by comparing the two sides of the figure. The right side is slightly lower in level than the left and shows the greater transition. On the left the antero-lateral projection is smaller than in S. 1. It is separated by a slight depression from the postero-lateral projection, which is relatively much larger. The last named projection is also divided by a slight depression into a larger mass in front (corresponding to the postero-lateral group of cells) and a much smaller portion behind (corresponding to the post-postero-lateral group). These projections may be termed respectively *postero-lateral* and *post-postero-lateral*.

On the right, the apparent antero-lateral projection is really composed of the combined antero-lateral and postero-lateral projections. The antero-lateral, greatly diminished, is separated by a very slight surface depression and a narrow zone of medullated fibres from the postero-lateral mass. This, again, is, by a depression deeper than that on the left side, separated from a large projecting mass, which is formed by the greatly increased post-postero-lateral group. Thus on the right side the postero-lateral mass has occupied part of the area of the antero-lateral group of cells, and has itself been displaced forwards by the enlarging post-postero-lateral column.



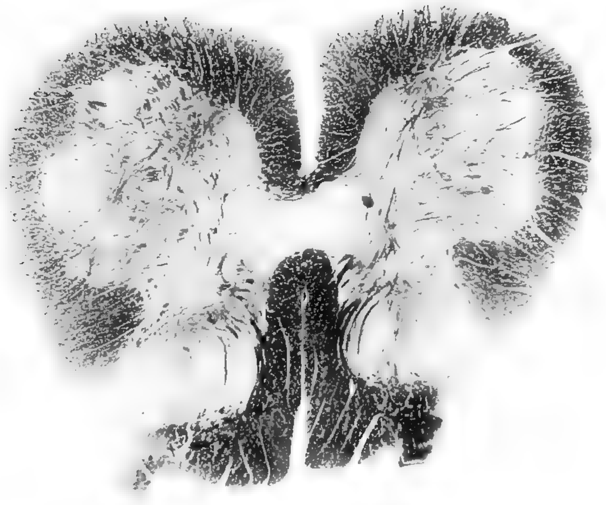


PLATE XXIX.

Third Sacral Segment.

A

S. 3. a.—(Upper part of Segment).

The anterior mesial group has reappeared and consists of five cells.

The antero-lateral group has disappeared. Its place is occupied by the postero-lateral group of seven cells.

The post-postero-lateral group consist of twenty-two cells arranged in an outer and an inner group of nearly equal size.

Between the mesial and lateral groups there is an area in which there is a large number of cells of very small size.

S. 3. b.—(Lower part of Segment).

The anterior mesial group consists of three large cells. There are five cells of smaller size slightly lateral to these.

The lateral group consists of sixteen cells, of which six belong to the postero-lateral and ten to the post-postero-lateral group.

Behind and internal to the latter, the intermedio-lateral group appears as sixteen small cells.

Between the mesial and lateral groups, there is a large number of cells of very small size.

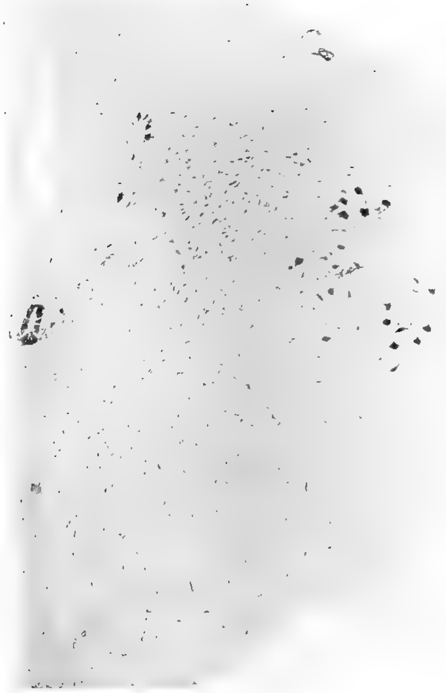
B

The anterior cornu has greatly altered in form.

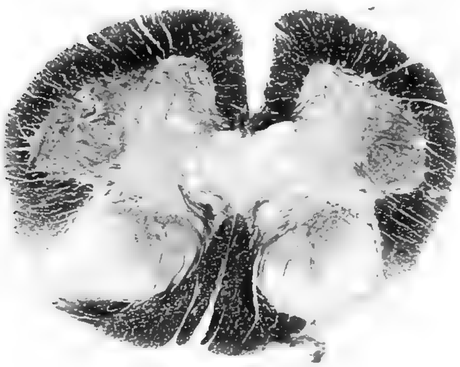
The anterior mesial angle has become acute, and forms the most ventral projection of the cornu.

The antero-lateral projection has disappeared, and the margin of the cornu is formed by a continuous curve from the anterior mesial angle to the posterior (post-postero-lateral) projection.

The posterior cornu is relatively much shorter and broader than in S. 2.



S.3.



S 3

PLATE XXX.

Fourth Sacral Segment.

A

The anterior mesial group has increased to ten cells of large size.

The lateral group is entirely unrepresented.

The cells of the intermedio-lateral tract are too faintly stained to be distinctly seen.

B

The anterior cornu has much the same type of outline as in S. 4.

The posterior cornu has a very broad neck.

The angle between the anterior and posterior cornua is, on the left side, very obtuse, and on the right side replaced by a continuous curve.

The anterior and posterior cornua are nearly equal in size.

The posterior commissure is three times as broad as the anterior commissure.

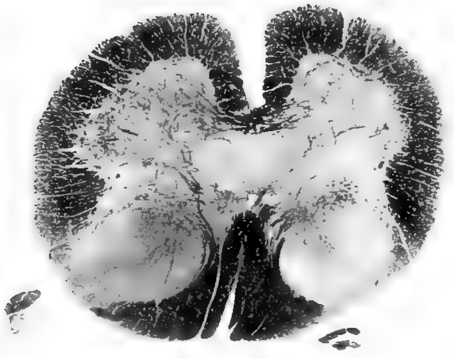


PLATE XXXI.

Fifth Sacral Segment.

A

The motor cells are entirely absent.

B

The anterior cornu has the same type of outline as in S. 3, and S. 4, but it is smaller than the posterior cornu.

The posterior commissure is, relatively to the anterior commissure, larger than in S. 4.

PLATE XXXII.

The Coccygeal Segment.

Its small size, the absence of distinction between the anterior and posterior cornua, the large amount of neuroglia round the central canal, and its projection on the surface posteriorly are to be noted.

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